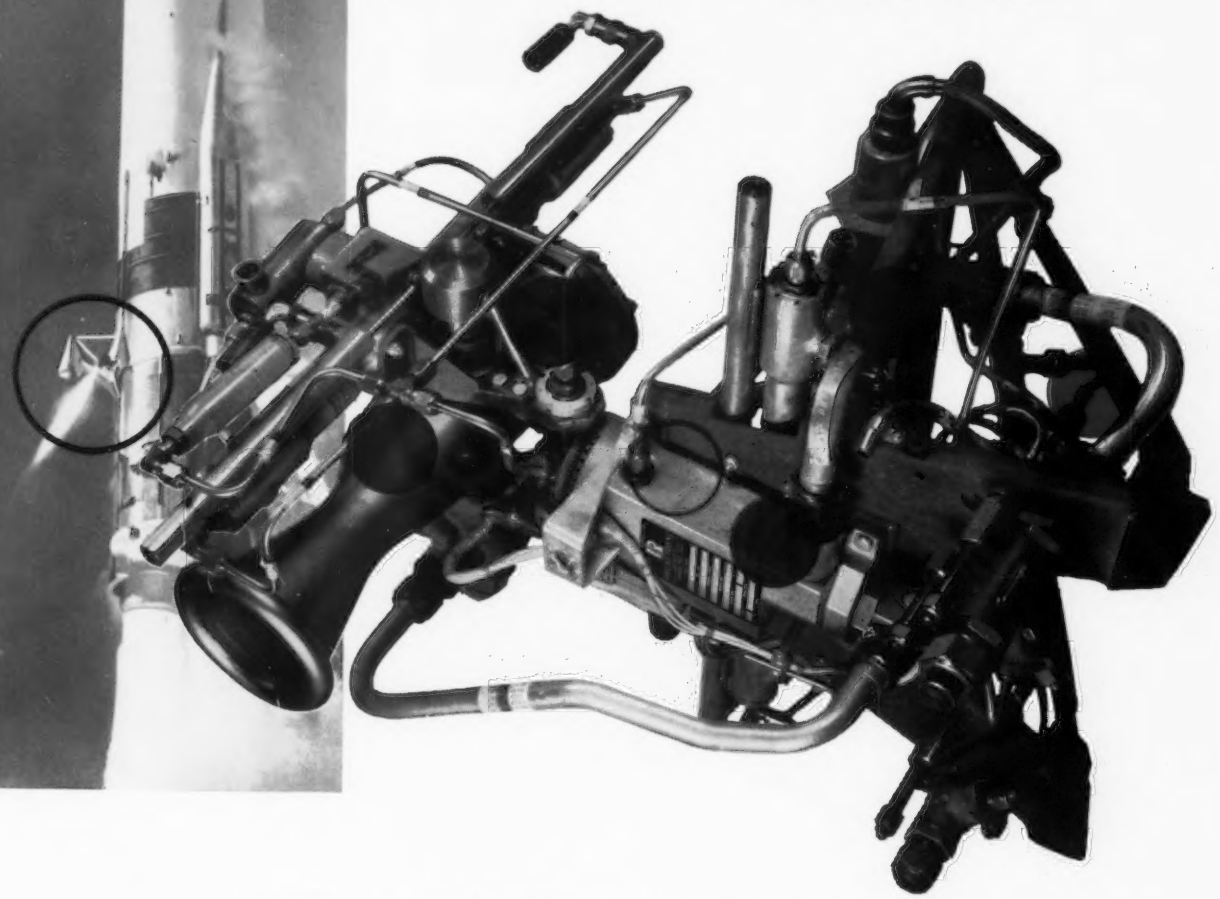
AIRCRAFT AND MISSILES MANUFACTURING

A CHILTON PUBLICATION

OCTOBER 1958



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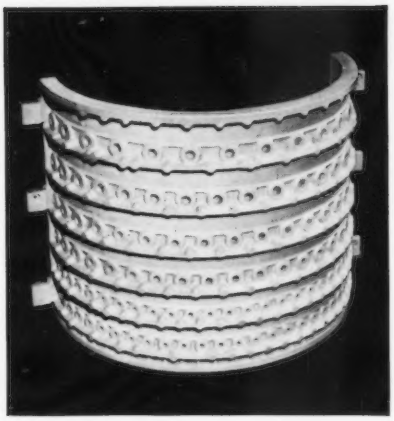
Zirconium, thorium, cerium . . . strange names for little known, little used elements. But add them to magnesium, and a new family of metals appears. Preserving the high strength-weight ratio of the featherweight metal, they add high-temperature properties that have proved a necessity in high performance aircraft and missiles. A specialist in light metals casting, Rolle knows these alloys as you know the back of your own hand.



how to save weight at high temperatures

an introduction to the magnesium-rare earth-thorium alloys

One-fourth the weight of steel . . . two-thirds the weight of aluminum . . . magnesium has carved a featherweight niche for itself in modern materials engineering.

But the reputation won by the magnesium-aluminum zinc alloys was won at room temperatures. Where high temperatures obtain, the "structural" alloys are no longer structural, and the lesser known "premium" group comes into its own.

These alloys, providing excellent high temperature properties and creep resistance to 660F, are also characterized by

- uniform strength of varying cross-section
- high fatigue strength
- low notch sensitivity
- freedom from microporosity
- good stress rupture characteristics
- good founding qualities

Naturally, properties vary within the group, but a rough comparison of individual advantages can be drawn.

a profile of the "premium alloys"

ZK51A and ZE41XA are superior, fine grained alloys with high yield strength and ductility, excellent fatigue properties, low notch sensitivity, and they are pressure tight without impregnation. Alloy ZH62XA offers these same general properties but is stronger than ZK51A. The room temperature strength of ZH62XA is combined in a relatively new alloy, ZH42, with creep resistance to 480F.

Complete freedom from microporosity, excellent founding properties, and low heat treating temperatures, characterize EZ33A, a magnesium-zirconium-cerium alloy. Like ZH42, EZ33A resists creep to 480F, and possesses good tensile properties at both normal and elevated temperatures.

HZ32A, perhaps the most important alloy of the series, contains thorium rather than cerium. Equal to EZ33A in strength, founding properties, and heat treating characteristics, it resists creep to 660F.

ideal for engine castings

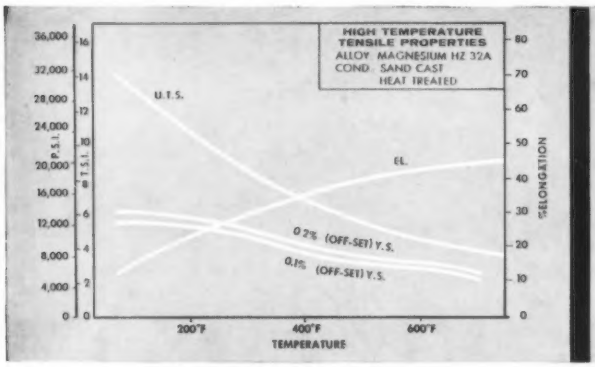
Though each of these "premium" alloys offers specific advantages, the benefits of HZ32A have undoubtedly been most impressive. Its unique heat resistance properties permit weight savings in stressed turbine engine parts with magnesium castings for the first time. A typical example is the part illustrated above . . . a jet engine compressor housing . . . sand cast by Rolle in HZ32A. Success of this alloy in such applications can be inferred from the two graphs—High Temperature Tensile Properties and Creep Resistance For Specified Plastic Strains.

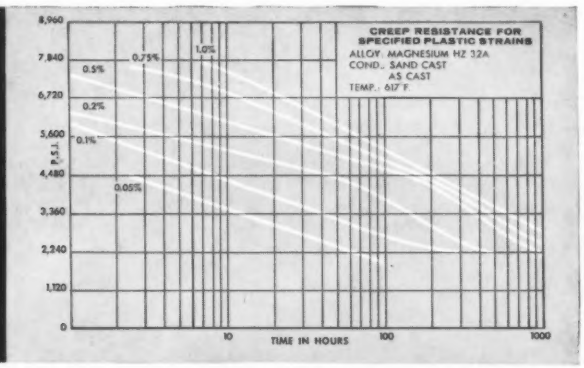
maintaining specified properties

Chances are you spend hours . . . even days . . . studying the "book" specifications of a metal before you design it into a part. But the book you've been working with too often gets thrown out the window with the first production run. Getting the most out of the premium alloys and into the cast part is often a difficult task, but we feel we're in an ideal position to do just that. Sand, shell, and permanent mold casting the *light metals* . . . and *only* the light metals . . . is our business.

fifty-eight page engineering manual

A considerable amount of data on the design properties of the aluminum and magnesium alloys can be found between the covers of our light metals casting manual.





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ROLLE

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Tremendous pressures and temperatures are generated in this shock tube at Lockheed Aircraft Corp., to simulate conditions encountered by a long-range ballistic missile re-entering the earth's atmosphere. High pressure gas triggers shock waves which travel 17 times the speed of sound. Instantaneous temperatures range above 15,000 degrees F.

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Simplify your design problems by calling *ESCO* for special alloy steel Spuncast pipe, standard heavy wall fittings, and special design fittings and valves.

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Circle 116 on Inquiry Card, page 81

contents

OCTOBER 1958

VOLUME 1, NUMBER 10

DESIGN
PRODUCTION
PROCUREMENT

A CHILTON PUBLICATION

THE COVER STORY

The small "vernier control" engines with less than one per cent the thrust of the main engine, play a big part in controlling precisely the attitude motions of the Atlas. The reputation this missile has maintained as the mightiest of present ICBMs, is already being challenged by "bigger and better" progeny in development. Recent announcements made by Rocketdyne leave little doubt that the heavyweight class of near-future rocketry, rated in millions of pounds of thrust, will render the Atlas the Kitty Hawk model of the ICBMs.

PAGE FEATURES

6 personalized quality control
10 "last of the fighters"
16 Boeing 707 fin tip
21 vernier engines
24 tool-up for Convair 880
26 missile gaging
30 first Earth-scanning satellite
33 precision-sizing sheet stock
36 tilt-wing VTOL
40 homogeneous fiber-polymer
42 short-haul versatility
46 hydraulics-contamination control

DEPARTMENTS

PAGE

5 editorial orbit
50 zero infinity
53 producibility review
55 materials and components
58 new for production
61 men on the move
63 worth asking for
79 readers' orbit
80 your date book

INDUSTRY NOTES

65 Atlas all - inertial system ready
66 radiation effects on nuclear aircraft studied
68 profits raise salaries of aircraft execs
69 fire-fighter of the near future
69 world-wide weather reconnaissance
71 missile mobility
72 VTOL-STOL aircraft
72 liquid fluorine harnessed
73 new gyro assembly installation
74 space applications for air-steel X-200
74 billions for air force defense
74 Boeing team receives dyna-soar assignments
75 target—moon
76 terra-scope
78 industry statistics

staff | AIRCRAFT AND MISSILES MANUFACTURING

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Automatically Operated
Remotely Controlled
PNEUMATIC PRESSURE REGULATOR

SAFE! Unprecedented in response and sensitivity. Not only does Marotta's new RV-23E Regulator Series load and vent pressure with push-button efficiency over a wider pressure range than any existing regulator or series of regulators, but is the only regulator meeting automation demands ...the RV-23E can be programed to operate systems at a different pre-determined pressure level sequence.

SPECIFICATIONS:

Model:
Regulator—¼" dome loaded pneumatic pressure reducer
Remote Control type 24 V. D. C. Solenoid operated

Pressure Characteristics:
Inlet, outlet, and gage ports per MS 33656-4
Inlet pressure range—30 p.s.i.g. to 6000 p.s.i.g.
Proof pressure—9000 p.s.i.g.
Burst pressure—15,000 p.s.i.g.
Outlet pressure range—30 p.s.i.g. to 5000 p.s.i.g.
Proof pressure—7500 p.s.i.g.
Burst pressure—12,000 p.s.i.g.
Rated Capacity 0.1 (SCFM PSIA) min
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PRV-11A Special 6", 160 psi LOX Pressure relief

MV-74-H ¼" three-way 6000 psi General Purpose Solenoid

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Making major breakthroughs in brazing stainless sandwich

Two radically new process developments by Temco Engineering may well revolutionize the entire concept of fabricating stainless steel honeycomb structures. One is "Temcombing," Temco's *continuous process* of stainless sandwich fabrication. The other is a simplified "Two-Phase" method for brazing stainless honeycomb structures. Patents now are being applied for on both of these processes.

Conventional, time-consuming batch brazing methods seem primitive compared with Temcombing. Panels of virtually unlimited size now are feasible in place of small, batch-made panels, thus reducing weight and critical tolerance errors. After lay-up, finished Temcomb panels can be turned out at rates up to 18 inches per minute, and at considerably *lower costs than by batch methods.*

Temco's exclusive Two-Phase resistance brazing method eliminates the need for furnace operations. For complex shapes, the Two-Phase process is the fastest and most advanced developed to date.

Advanced weapons systems, probing beyond Mach 3, demand whole new domains of materials and reliability. Temco engineering capabilities are meeting these demands with new developments and fabrication techniques in stainless steel, titanium, and other high-temperature materials. Pioneering in design, tooling and production for tomorrow's spacecraft industry is part of Temco's complete systems capabilities — all ready to meet *your* challenge.

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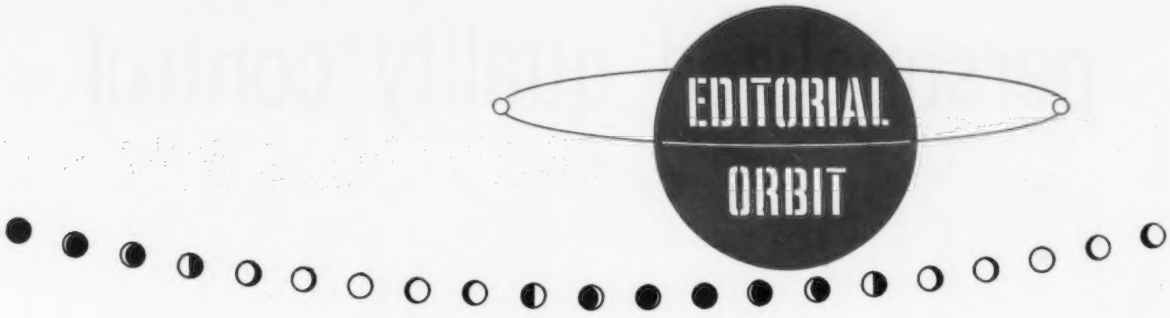
TOMORROW'S NEED IS TODAY'S CHALLENGE AT..



which yardstick for progress?

On October 4, one year ago, the voice of the first man-made moon, Sputnik I, issued an unprecedented challenge to self-assured American leadership in space technology. The challenge clearly put us in a race to regain lost ground.

The achievements of a "backward nation" have completely upset our yardstick of progress.

Despite public statements reflecting official glibness, investigations and reappraisals of our space and missile programs have followed each other rapidly. With accompaniment of reassurances that we are not in a race, the following important measures were taken during the past twelve months.

- Appointment of Dr. James Killian as special science advisor to the White House.
- Organization of the Advanced Research Projects Agency.
- Organization of the National Aeronautics and Space Administration.
- Dusting-off the shelved Jupiter C.

Legislation for the above would normally have taken years but the recognition of an emergency prompted immediate action.

In addition, an assessment of our educational program has revealed the need to emphasize science, and to study the Russian language.

Contract has been let for the development of a 1 million-pound thrust rocket engine.

All major aircraft companies have created or are in the process of creating special space-technology divisions.

The Atlas program, barely started in 1953, was scheduled for availability in 1965. This rate of progress was calculated to maintain our leadership in world technology. After Sputnik I, development time was cut to nearly one third, and delivery date of 1959 was established.

The Polaris missile program has been accelerated twice and will be stepped up again as soon as Secretary of Defense has the available funds.

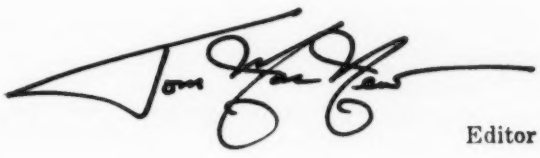
Meeting Schedules Is Not True Measure of Progress

The ill-fated lunar probe was conducted on such a tight schedule that some of the payload electronic gear was still in "bread board" stage little more than a week before launch. Urgency necessitated award of prime contract for the probe to Space Technology Laboratories without competitive bids. The officially stated one-to-ten odds for success of the vehicle fired on August 17 were extremely optimistic. Possibly, a delay of launch date by one month would have increased the reliability of the project.

As it was, the only accomplishment claimed was that the shoot went off on schedule. The statement, "the most amazing thing is that it got off the pad," made by an Air Force General, has serious implications.

The undeniable fact is that progress is a slow process and it cannot be legislated. The most enthusiastic programs will not get past the drawing board, and vehicles may continue to go up in monumental balls of fire if the tedious scientific process is not followed in designing, fabricating, and evaluating every last valve and fastener on a missile or spacecraft.

We have no reason to be embarrassed in accepting the challenge; we are in contest and we should be in it in earnest. Let us only hope that we profit from past mistakes without being goaded into premature attempts to pass the opponent.



Editor

personalized quality control

system used for short-run production motivates individuals and teams to improve past performance

by **Curt Williams,** manager quality control, component manufacture and engine rebuild section, General Electric Co.

Jet engine component manufacturing losses were cut 45 to 50 per cent in nine months at the General Electric Components Manufacture and Engine Rebuild Section at Evendale, Ohio, due to a personalized quality control system.

According to a general attitude in the aircraft and missile industry, statistical quality control methods are not readily adaptable to the prevailing types of products and the relatively short production runs.

This has been refuted by a method of combining and pyramiding attribute data from an individual work station to a composite of all operations. The resulting system is adaptable to changes and to short-run production. With it, quality trouble areas are forecast and preventive action is initiated before hand. The basic method of approach involved the following phases:

1. A plan of action for a recognized problem.
2. A program for the accomplishment of the plan.
3. Unification of efforts from all involved.
4. Measurements and evaluation of results obtained from single operators and from groups.

The measurement of current individual machine operator performance against a norm of previous individual accomplishment, is the novel concept developed in this system. Here the machine operator becomes the keystone.

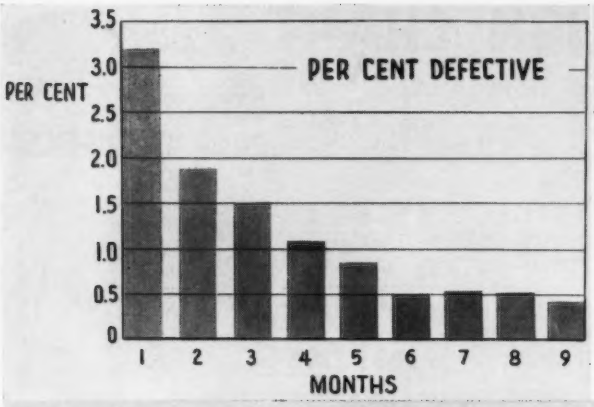
The average performance of each machine operator was selected as the quality control level for introduction of the system, with the requirement that each machine operator perform to his average or below (the average performance being in terms of unfavorable characteristics or dimensions produced). Three charts are used to record the pyramiding effect of quality extending from operator to manager.

In-Process Inspection Record

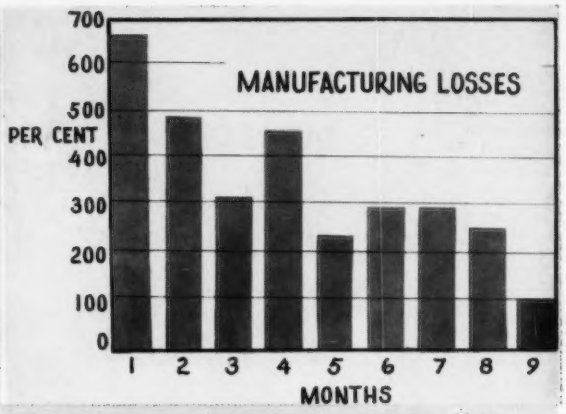
Completed by the inspector and fed to quality control engineering, it is the primary document from which all statistical quality control records and reports are generated. The operator's job is divided into measurable segments. These are called characteristics, and refer to a dimension, surface finish, hardness requirement, or any other result the operator is to produce. As in the initial stages of establishing the plan, where no precedent exists data compiled over a period of 30 days is compiled, recorded and plotted. The average quality level maintained by this operator is then used for the upper control limit for the next month's output. Any time his per cent defectives are greater than his previous month's average, he is considered to be out of control and immediate corrective action is initiated. The same norm is used for the foreman, general foreman, and superintendent.

Foreman's Summary Sheet

The performance of each operator is summarized daily on this form. The performance level of the foreman is based on the combined



Reduction of defective pieces in jet-engine component manufacture due to personalized quality control system.



Reduction of jet-engine component manufacturing losses, resulting from personalized quality control system.

performance levels of all his operators. In and out-of-control conditions are shown by the use of green and red circles. Red indicates that immediate action is required by the foreman to correct the cause. Green denotes progress and improvement from past performance. This form is duplicated for use by the general foreman in measuring foremen and by the superintendent in measuring general foremen.

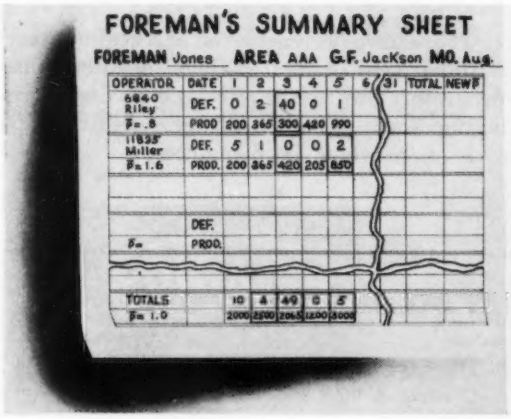
Action Chart

This chart indicates quality control trouble areas to the plant manager. It reflects the actual pyramiding effect of quality from the operator to the manager, and shows all concerned the exact point where an out of control condition exists. Pinpointing of trouble-spots enable the superintendent to initiate prompt corrective action. A minimum of his time is involved because only the serious quality control problems come to his attention.

Operational Structure

Reporting to the manager of quality are the various supervisors of inspection as well as the supervisor of quality control engineering department. Quality control engineering is kept out of the firing line to afford the department an

The performance level of the foreman is established from the combined performance of all his operators.

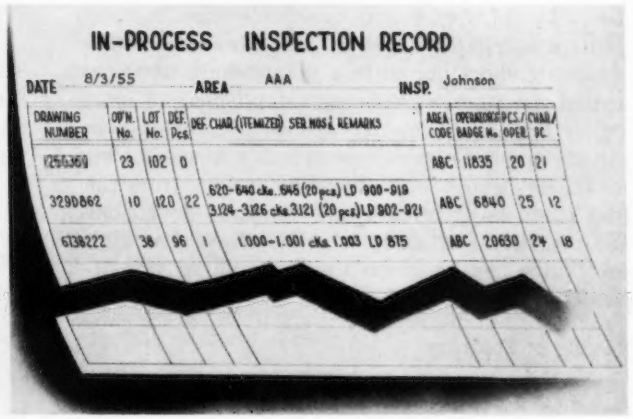


FOREMAN'S SUMMARY SHEET

FOREMAN Jones AREA AAA G.F. Jackson MO. Aug.

OPERATOR	DATE	1	2	3	4	5	6	31	TOTAL	NEW F
6840 Riley	DEF.	0	2	40	0	1				
F = .8	PROD	200	365	300	480	990				
11835 Miller	DEF.	5	1	0	0	2				
F = 1.6	PROD.	200	365	420	205	850				
	DEF.									
F =	PROD.									
TOTALS		10	4	49	0	5				
F = 1.0		2000	2500	2065	1200	3000				

This form which is completed by the inspector, furnishes the basic information for the quality control system.

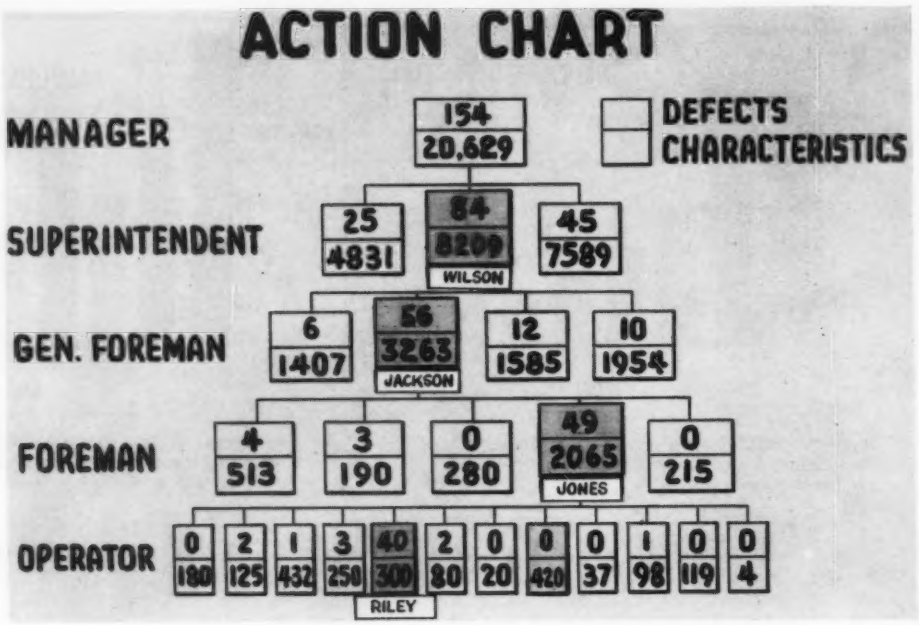


IN-PROCESS INSPECTION RECORD

DATE 8/3/55 AREA AAA INSP. Johnson

DRAWING NUMBER	OP'N. No.	LOT No.	DEF. Pcs.	DEF. CHAR. (ITEMIZED) SER. NOS. & REMARKS	AREA CODE	OPERATOR'S BADGE No.	PCS./ OPER.	CHAR./ PC.
1250360	23	102	0		ABC	11835	20	21
3290862	10	120	22	620-640 cks. 645 (20 pcs.) LD 900-919 3124-3126 cks. 3121 (20 pcs.) LD 902-921	ABC	6840	25	12
6138222	38	96	1	1.000-1.001 cks. 1.003 LD 875	ABC	20630	24	18

Pyramiding effect of quality from operator to manager is illustrated by the action chart.



personalized quality control...

continued

unbiased attitude in decisions. Under quality control engineering, requests are made through the inspection supervisors for the compilation of inspection data. The data are then analyzed, and all the charts on the operators, foremen, general foremen, and superintendents are maintained; also weekly and monthly reports are issued. All corrective action for the operation of this system emanates from quality control engineering. An important feature of the system is the prompt evaluation of performance at all levels, from the machine operators' through the manager's with uniform interpretation of data. A monthly review of individual performance is compiled, and adjustment of standards are made to correct averages.

The system was introduced slowly in selected areas with no major disruption of schedules. As its application was broadened, a competitive spirit developed which snow-balled in a relatively short period to a point where unprecedented averages were being established.

The program, by virtue of working in comparison with previous month's average, immediately brings to attention deviations from the previously established norm. Since all deviations are recorded and analyzed, those having a high cost value can be given the most immediate attention.

Results of Program

After a year of operation, forecasting learning curves has become a reality. Through the program, the number of defective parts and amount of scrap produced each month are plotted while an operator is becoming familiar with a new operation. Since this type of data has now been compiled on several hundred operators, established daily, weekly, or monthly efficiency levels can be reviewed and future learning cures predicted.

The following are the benefits derived from the personalized quality control system.

a. Manufacturing losses cut 45 to 50 per cent in nine months.
b. Jet engine component defective pieces cut 83 per cent.
c. Manufacturing overrun cut about 70 per cent in one year.
d. Customer rejections of major jet engine assemblies cut 23 per cent in one year.

These have been achieved at a cost between 8 and 10 per cent of total savings resulting from the program. The resulting competitive spirit is motivating each operator and aggregate team to improve on previous performance.

◆

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of this article can be obtained by writing on company letterhead to
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Chestnut & 56th Sts., Philadelphia 39, Pa.

What's the coolest insulator for hot products?

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This is the heat insulator Formica research developed by combining great mechanical strength with high heat resistance. It has helped break the heat barrier in aviation, missile and space craft.

This type of heat insulator can be useful in your hot products, too. In fact, product designers are getting more "assists" from Formica laminated plastics than any other material. Standard grades available for immediate use in your projects . . . without extensive delays for research and development. Forty-eight hour Streamliner shipment of most grades. For further information, write for bulletins 829 and 856-A. Formica Corporation, subsidiary of American Cyanamid, 4537 Spring Grove Ave., Cincinnati 32, Ohio.

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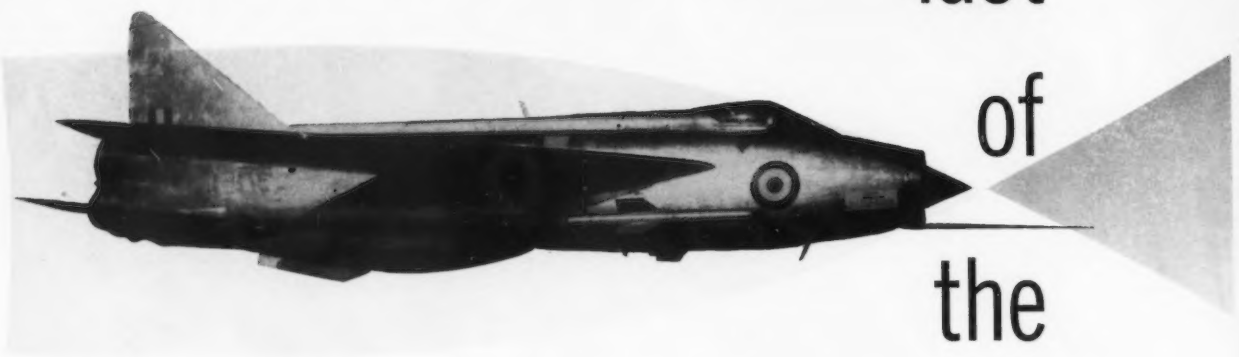
FI-1966

Circle 119 on Inquiry Card, page 81

English Electric P.1B "Lightning," called the "last of the manned fighters" by the RAF, first flew in the basic P.1 configuration in 1954. Speed of sound was exceeded on the first flight without pilot realization. This attests to aircraft stability.



"last of the fighters"

P.1B designed to peak R.A.F. standards; twin turbines, twin rocket boosters, area rule, and 60 deg sweepback give mach 2+ performance

Many types of fighter aircraft have been argued about for the defense of Europe. In the main, each type has been of a specialized nature.

There are the proponents of the light fighter who would cut the standard armament from four to two 30 mm cannon and make little allowance for weapon carrying.

There are the mixed power enthusiasts who propose fighters with a powerful rocket thrust aiding turbine power in climb and combat. Rightly, they claim that only rocket thrust could give adequate performance at high altitude. Used by the Germans during the last war and called "target defense interceptors" this class of aircraft is virtually a manned missile.

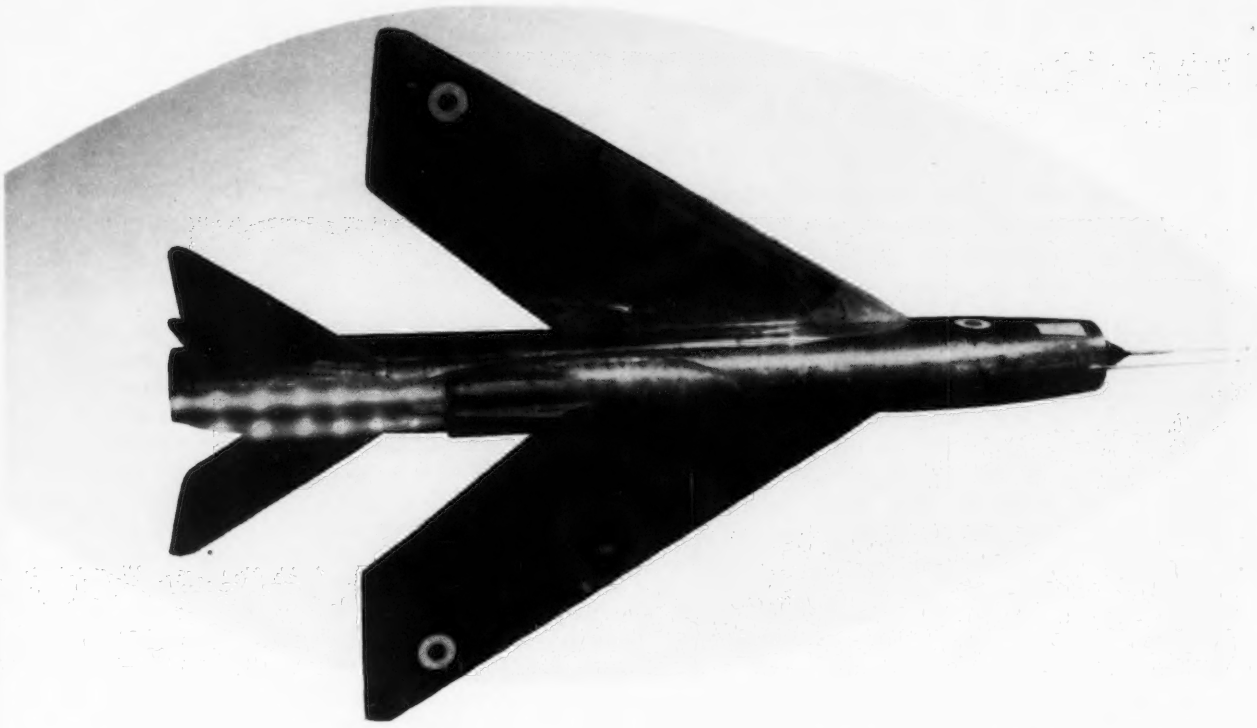
Most of these specialized schemes were dropped when the RAF (Royal Air Force) decided to adopt the English Electric P.1 "Lightning" series. Termed by some "the last of the manned fighters," it was conceived with versatility as the major consideration. In appearance it is quite unusual, and unlike anything flying in eastern or western skies. It is big and consequently heavy. It is powered by a "piggy back" mount of two Rolls Royce Avon engines, which receive an assist from a Napier Double-Scorpion rocket motor to improve rate of climb and high altitude performance. Wings have a wide chord and a 60 deg sweepback. Fuselage incorporates "area rule" throughout, though no bulges are apparent. It has Mach 2+ performance capabilities.

Standard armament consists of two de Havilland Firestreak infrared homing missiles carried on small stubs fitted to the lower fuselage ahead of the wing, and two 30 mm Aden cannon enclosed in the fuselage next to the cockpit. There is sufficient development potential to meet the needs of all future missiles now planned by RAF.

P.1B first flew in April, 1957. Twenty preproduction aircraft were ordered to speed development. A two place trainer is now complete, and an all weather version is not far off.

General Description

Engine disposition and intake design strongly influence the overall layout of most modern aircraft. In P.1B, two Rolls Royce Avon turbojet engines are tailored into the almost parallel



P.1B can cruise on one or both of its Rolls Royce Avon engines. Napier Double-Scorpion rocket motors mounted in ventral pod can be used singly or in pairs for acceleration and climb.

Partially completed wing section shows how main spars bend in hockey stick fashion where they enter fuselage. Had they been extended in a straight line, air intake would have been obstructed. Wing sections join at heavy forging on fuselage center line.

fuselage. Air enters through a circular pitot type intake having a conical, radar-housing center body shock generator. The intake tunnel passes under the cockpit floor to a settling chamber and then to the engines via a forked duct. Placing one engine above and behind the other has given minimum fuselage cross section.

To date Avon engines have been unofficially rated at a dry thrust of 11,250 lb. Twice this power, plus afterburning, would give P.1B a sea level static thrust in the region of 30,000 lb.

The compression ratio of the engine working on the already compressed supersonic flow gives very high temperatures in the final stages of the axial flow compressor. For this reason steel blading is employed.

Provisions are made for a quickly detachable pod containing a Napier Double Scorpion rocket to be carried under the fuselage. This pod takes the form of a streamline slipper with the rocket barrels pointing diagonally downwards. It is a self contained pack having an integral HTP (High Test Peroxide) tank, a nitrogen system for purging in flight, and its own electrical system.

continued on next page

The kerosene fuel supply is drawn from the aircraft fuel system. Use of a double barrel unit is in keeping with the general powerplant design. Either one or both barrels may be ignited.

Area Rule and Sweepback

By designing for area rule from the start, and using accurate tunnel testing techniques, it was possible to derive an aircraft devoid of unsightly, "unfunctional" bulges. In-flight buffet, wing drop, and excessive trim changes are also designed out. Recently, while flying supersonically, the controls were crossed and then let go. The aircraft stabilized itself "perfectly" according to the test pilot.

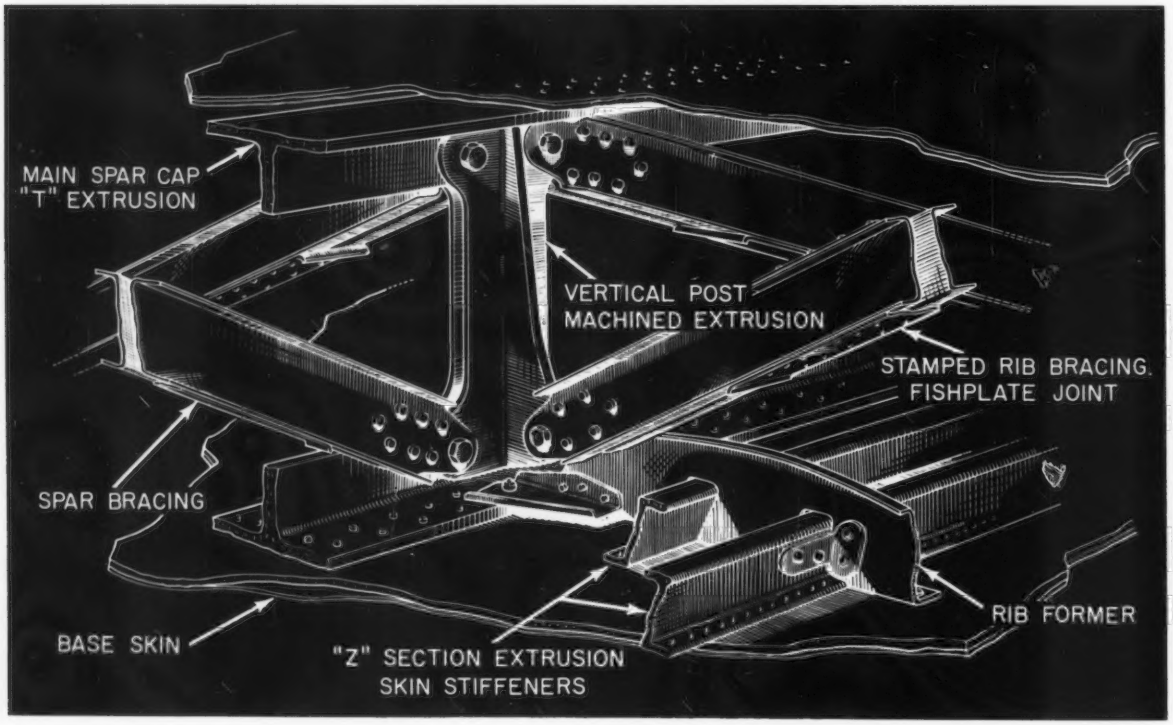
Sweeping the tailplane at about the same angle as the wings is part of the plan to distribute frontal area along the fuselage length. The horizontal tail surface is a single slab, and is placed well within the immediate wing wake, slightly below the center of vortex. Tunnel tests showed that at this point the wing downwash decreases with increased incidence and gives a strong stabilizing effect.

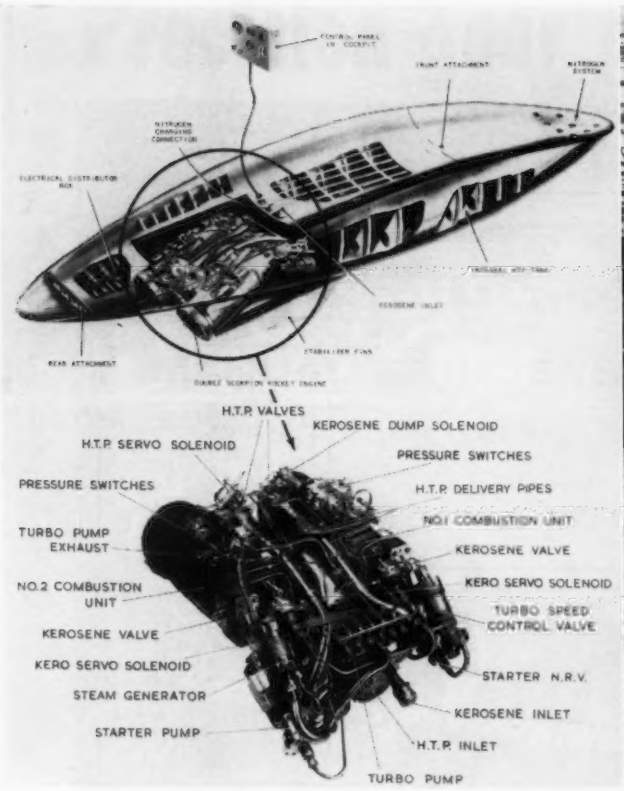
Structure

No complete details of the thin 60 deg swept wing have been made available. A general survey indicates a wing of this shape has to carry appreciable bending moments and shear forces both along and across the span. The chordwise loading would be very high in the vicinity of the root.

In P.1B there are five spanwise spars which combine with a number of evenly spaced chordwise ribs to provide a stiff matrix. Each wing continues through the fuselage side to join the other on the fuselage centerline. Mounted at mid-fuselage position the wing roots pass between the two engines. The front spars are bent in a hockey stick form at their root ends. Thus, they enter the fuselage at right angles to the skin

Rolled stock 0.20 in. thick is used for top and bottom wing skins. Light alloy "T" extrusions form top and bottom caps of main spars, diagonal braces are sheet pressings. Riveted "Z" section extrusions are used as skin stiffeners.





Napier Double-Scorpion rocket motors are powered by hydrogen peroxide and kerosene. Greatly increase high altitude and climb performance.

Special vertical riveting jig is used for wing skins. Panel is held at correct profile while riveting head follows a sympathetic path. Two operators are used.

line. Had they been carried forward at the angle of sweep, they would have obstructed the intake tunnel.

The three remaining spars, and all except one of the chordwise root ribs, have "N" girder design. Only outboard of the main landing gear hinge do the ribs change to diaphragm form. This feature, together with the use of plate webs on the front and rear spars, denotes that the wing is too thin in relation to the shear it carries for the best use of tension field beams.

Most of the wing volume is used for fuel stowage, although wheel wells and retraction mechanism use a lot of space in outboard wing section. Tankage is of the integral type and consequently poses a sealing problem. A double line of sealant is applied at all mating surfaces.

To improve lift at low speeds the wing leading edge is hinged to "droop." Large area split flaps run almost the entire span of the trailing edge. Ailerons have thick trailing edges and are fitted with tip horn balances as well as mass balances. They are power operated to provide positive and rapid maneuver without feed back.

Rolled sheet stock 0.20 in. thick is used for the top and bottom skins. Where necessary these are reinforced by extra laminations of various gauges, and wherever possible they are thinned by surface routing. These measures give a nearly uniform maximum stress loading throughout the surfaces. Light alloy extrusions of "T" section form the top and bottom caps of the main spars. These are joined by verticals machined from another "T" extrusion, and diagonals which consist of two sheet pressings joined by fish plates. All these intermembers are attached by a single bolt to give a pin jointed structure. Stiffening of the skins between the girder spars consists of two "Z" section extrusions riveted in place so that they face each other. (See illustration.)

A diaphragm root rib diffuses loading into the fuselage skin via a multiple bolt joint.

Whereas the front and rear spars are continued across the fuselage the others are stopped at the fuselage side. At the point where each

"last of the fighters" . . . continued

SPECIFICATIONS FOR P.1B LIGHTNING

Wings: Cantilever mid-wing. Sweepback 60 deg. Thickness/chord ratio, 5%. Fore and aft notches in lieu of wing fences.

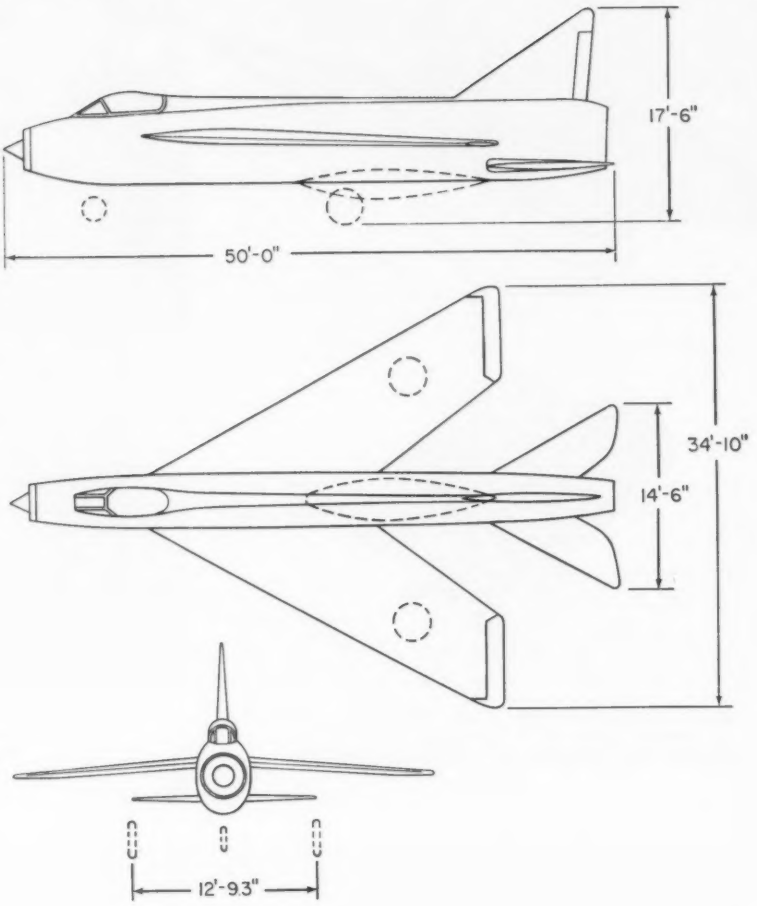
Fuselage: Parallel section. Area rule. Speed brakes, upper aft.

Tail: Delta, no trim tab. Single piece horizontal slab.

Landing gear: Tricycle, main gear retracts outward into thin wing. Steerable nose wheel retracts forward.

Cockpit: Hinged canopy, rearward. Martin-Baker ejection seat.

Dimensions: Span 34 ft 10 in.
length 50 ft 0 in.
height 17 ft 6 in.
tail span 14 ft 6 in.
wheel track 12 ft 9.3 in.



terminates there is a fuselage ring frame which picks up the loading. Both top and bottom skins are carried into the fuselage and terminate on a heavy machined center rib; extra stiffening is added to the skin over this portion. The complete fuselage structure is based on a series of ring frames, or hoops to which an inner skin is added to form the intake tunnel. Speed brakes hinge forward from the upper rear fuselage ahead of the tailplane.

A heavy built up "I" section spar forms the main member of the vertical tail stabilizer basis. This terminates in a large trunnion which rotates on bearings mounted in the rear fuselage.

Construction Details

Study shows that the whole design has been arranged for production using simple and readily available tooling. With perhaps only one or two exceptions, P1.B could be built using exactly the same methods and plant employed for aircraft production during WW II. The elimination of integral, milled-skin, stiffener panels and complex machined spar booms are cases in point. It is not known whether there is any saving, or loss of time and it would be indeed difficult to make an accurate comparison of this cost aspect. However, there is a strategic advantage in being independent of costly and comparatively rare machine tools.

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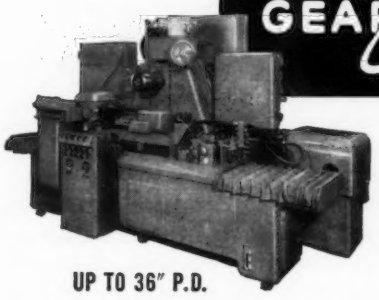

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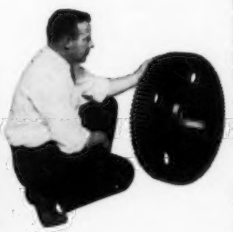

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epoxies play major role in tool-up and construction of electronic shield on jetliner

fin tip

by **U. W. Massie**, chief project engineer, Brunswick-Balke-Collender Co.

A section of the fin tip is laid up in its mold and excess air and resin are removed by both vacuum and squeegeeing.

Three different antennas and their related electronic gear ride high in the fin tip of the Boeing 707 vertical stabilizer. The probe on the leading edge of the tip is a high frequency transmitting-receiving antenna, two-thirds of the way back is a saddle-type flush high frequency receiving antenna, and a Loran antenna is in the trailing edge. The tip also contains lightning arresters for each of the antennas plus a high frequency and Loran couplers.

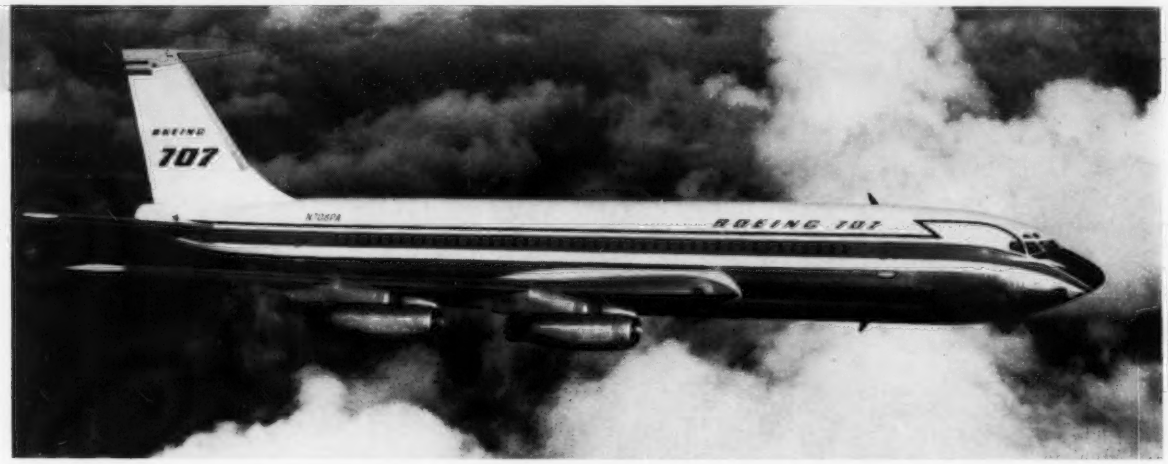
The material used to make the fin tip parts which houses this equipment must:

- be a good dielectric, in order to isolate the antennas from the rest of the airplane and prevent the possibility of grounding.
- be compatible with the electronic components operating with high frequency electronic impulses.
- be dimensionally stable under temperature extremes.
- shield the electronic gear from hail rain, dust, etc.
- have a high strength-to-weight ratio and good fatigue characteristics.

Boeing engineers selected a laminate construction, utilizing epoxy resins (Epon) and 181 glass cloth.

There are five sub-assemblies in the tip, four of epoxy laminates and the fifth of aluminum. Forming ribs are of aluminum. When assembled, the tip is over 9 ft long and includes 27

First production model Boeing 707 Jet Stratoliner made its maiden flight December 20, 1957. Now available in varying dash models 707 is expected to see scheduled service in early 1959.



PREPARATION OF EPON RESIN—GLASS CLOTH LAMINATES

WET LAY-UP METHOD

Curing Agent	Recommended Concentration	Pot-Life (1 Qt.) at Working Temp.	Maximum Lay-Up Time	Curing Procedure				
				Pressure	Precure (Min.)	Cure (Min.)	Curing Temperature	Post-Cure (If Desired)
With Epon 828								
diethylamino-propylamine (A)	8 phr	3-4 hours	4-5 hours	25 psi	2	28	240 °F	2 hours at 300 °F
Epon Curing Agent Z	20 phr	4-6 hours	6-8 hours	14 psi (vacuum bag)	0	90	185 °F	2 hours at 300 °F
m-phenylene-diamine (CL)	14 phr	4-6 hours	6-8 hours	25 psi 14 psi (vacuum bag)	13 0	47 120	212 °F 175 °F	1 hour at 400 °F or 2 hours at 300 °F

DRY LAY-UP METHOD

Curing Agent	Recommended Concentration	Useful Life of Resin Solution	Useful Life of Impreg. Cloth	Curing Procedure				
				Pressure	Precure (Min.)	Cure (Min.)	Curing Temperature	Post-Cure (If Desired)
With Epon 828 Epon Curing Agent Z	20 phr	1-3 days	7 days (77 °F) or 6 mos. (40 °F)	200 psi	3	15	290 °F	2 hours at 300 °F
m-phenylene-diamine (CL)	14 phr	1-3 days	7 days (77 °F) or 6 mos. (40 °F)	200 psi	15 at 200 °F 0	30 15	225 °F 290 °F	2 hours at 300 °F

separate parts. Part dimensions range from 2 x 12 in. to 2 x 3 ft.

Tooling Up

Epoxy resins also played a major role in tooling for the fin tip. In selecting this material instead of other tooling resins the sub contractor (Brunswick-Balke-Collender Co.) was governed by several factors related to production: the cost; the delivery time; the large quantities of parts to be produced; the high curing temperatures necessary; and the dimensional stability required of the molds.

Employing epoxy tooling resins enabled tooling up for the fin tip parts in less than six weeks. Metal tooling would have taken a minimum of fourteen weeks. Compared with other plastics the epoxies were considered easier to

Reinforcing ribs (also laminated epoxy) have been attached to the assembly fixture and the laminated outer shell is ready to be located for assembly.

Boeing 707 fin tip . . . continued

work with, possess greater dimensional stability, and produce a better surface finish. ("Plastic Tooling-Epoxies Move In," AMM, Feb. 58.)

Production requirements were upwards of 300 pieces per mold. Other types of tooling plastics might have proved more economical for shorter runs but it was felt they would not have lasted for an extended production run.

Tooling consisted of male and female molds of high temperature resin and glass reinforcement. Original mock-ups for the fin tip parts were fabricated with steel templates. Areas between the templates were swept in with a white tooling epoxy resin which worked easily and required no finishing.

Tool lines were laid out from these mock-ups and epoxy splashes made of each section to be cast as molds. To these splashes were transferred all print lines and other pertinent data. From the splashes, the high temperature epoxy resin tooling was constructed in two halves, joined together, and sealed to form the molds. The two halves were then mounted on a base to which all of the accessory equipment such as vacuum lines, stands, etc., were attached.

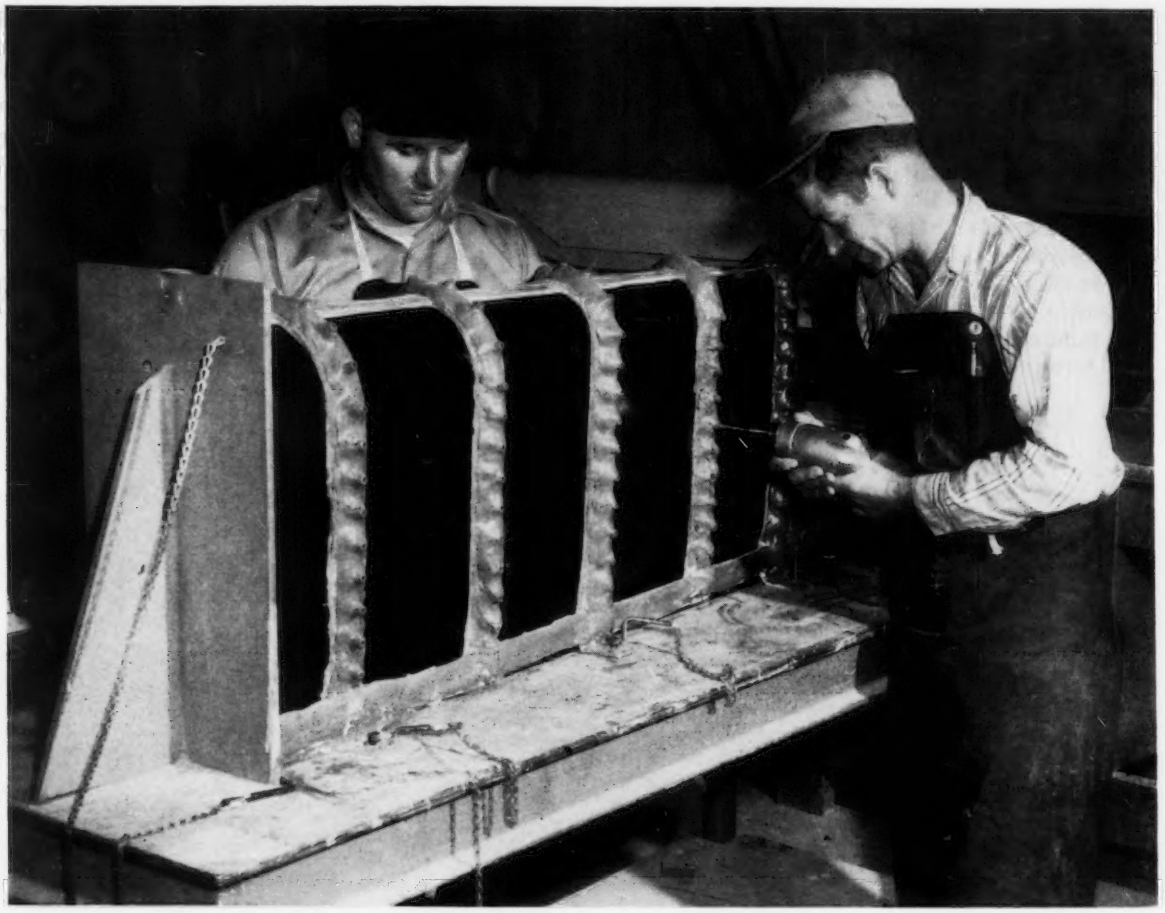
Laminate Construction

Before the parts were laid up. the molds were cleaned, with special attention being paid to the rivet locations and trim lines to ensure that they would print properly. The mold was sprayed with an acetate release agent and dried by forced hot air.

The thickness of a typical part layup was about 0.01 in. (10 plies of 181 glass cloth). Some of the parts around the attaching edges did have an extra 2 to 3 ply build-up.

After the laminator cut the cloth to a pattern that fitted a particular part, he obtained resin from the resin mixing room. The resin mixture was made up of 100 parts of Epon 828 and 17 parts of an amine catalyst. Resin and catalyst were mixed for a minimum of 30 min with a rotary stirrer equipped with slotted blades to prevent pulling an excess of air into the resin.

The glass cloth was spread on a table and saturated with the epoxy resin. The resin was "wiped" in, and the cloth draped over or in the mold, depending upon whether the mold was male or female. All excess resin was wiped out and discarded.



Drilling underway on aft section of the fin tip. Drill fixture was fabricated with a tooling epoxy resin.

A bleeder spring was placed around the edges of the part outside the trim line and fastened so that a vacuum hose could be attached to the assembly. A polyvinyl alcohol bag was draped and fitted over the mold and a vacuum drawn (about 20 in. of Hg). A space heater was placed over the mold to lower the viscosity of the resin; as the heat increased, it became easier to squeeze excess air and resin from the part. Resin content of 35 per cent by weight in the laminate was established as maximum.

When the correct thickness and resin loading had been established, the part was removed from the heat source and allowed to stand at ambient temperature for 8 hr until the resin had "B" staged. At this time the bag was removed and the part inspected for possible voids. Minor repairs such as sanding were made at this point. The part was then rebagged and placed in a high temperature oven for final cure. This cycle started at 150°F, and was raised 25°F each hour until 275°F was reached. At 275°F the part was cured for 4 hr and the temperature was then raised to 300°F for an additional 4 hr of post curing.

Reason for the curing method selected was by allowing the parts to reach "B" stage, the first and most critical part of the cure was completed. "B" staging the resin (or curing at low temperature) allows the resin and curing agent to reach more reactive points and yet react essentially in a linear plane. This results in lower exatherm temperatures with lower shrinkage, stains and distortion.

As the resin became gradually stiffer, air was prevented from entering the part. Each temperature rise in the final cure enabled the resin to cure at an optimum rate.

Tool Details

Each part of the fin tip was laminated in a different mold. Construction consisted of the

Boeing 707 fin tip . . . continued

flexible outer laminated skin mounted on a series of ribs. Once the skin was riveted to these ribs, it maintained its shape and contour. Ribs as well as the outer skins were produced from epoxy molds. Form blocks were then placed on the sub-assembly fixtures. The necessary drill bushings and locating plates were bonded into the assembly drill fixtures.

When all of the sub-assemblies had been completed, they were put together in a final assembly fixture where the parts were drilled and trimmed to properly fit each other and the vertical stabilizer.

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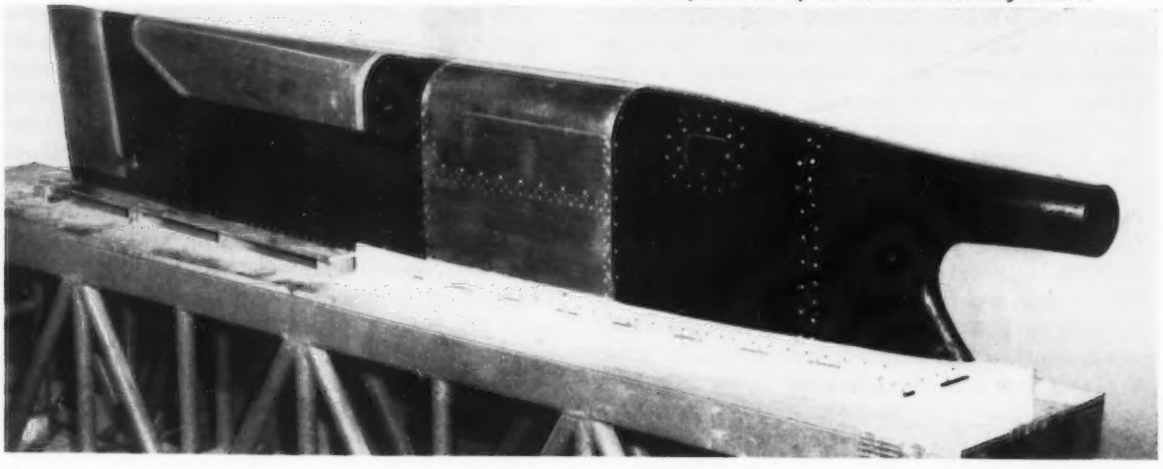
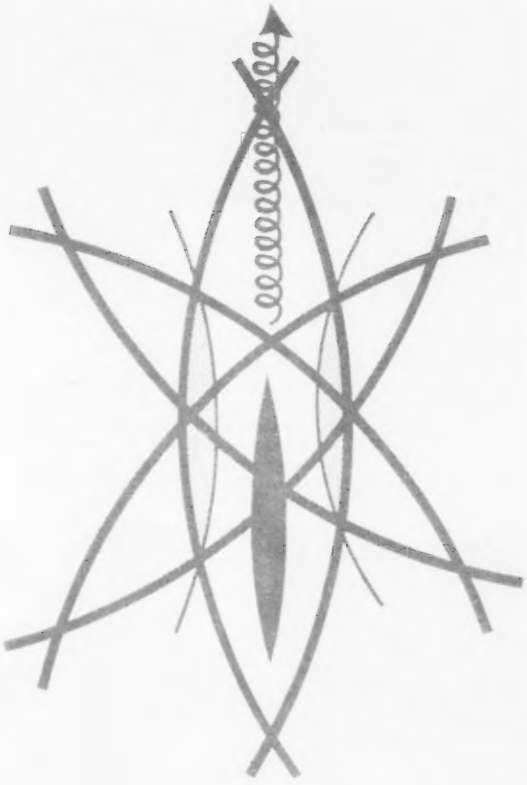
Forward section of fin tip in process of being assembled.

The completed fin tip in the final assembly fixture.





vernier engines

small rockets on ballistic missiles provide precision control of attitude and trajectory

by Robert McLarren

Two tiny jets of flame, issuing from opposite sides of the mighty Atlas, control the attitude motions of the missile in flight.

The two "vernier control" engines used for this purpose are self-contained rocket powerplants in themselves. Each engine functions as an independent unit receiving control signals from the missile guidance system.

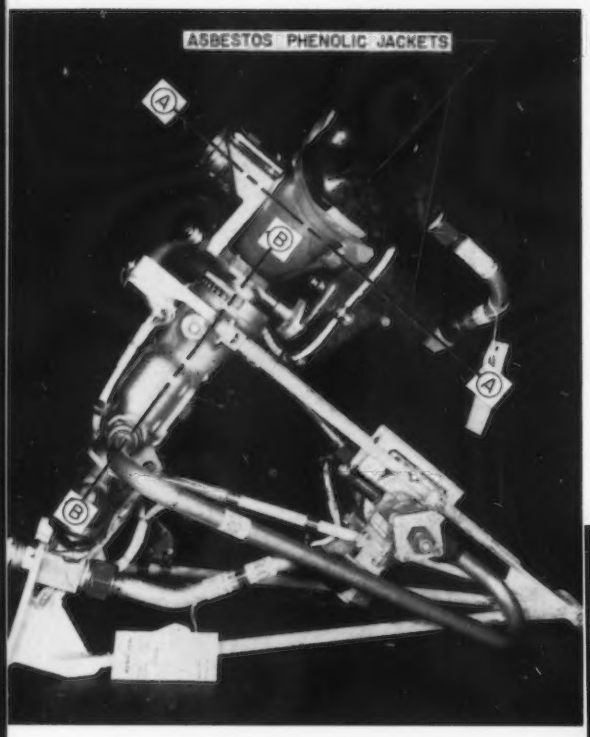
North American Aviation's Rocketdyne Division, Canoga Park, Calif. is the producer of vernier engine sets for the Convair Atlas and Douglas Thor ballistic missiles. These engines function as constant-thrust devices. Two engines working in unison provide precise and rapid variations in thrust to correct the slight deviations of missile attitude. For example, a change in missile direction may be accomplished by swinging one vernier engine out while rotating the other in. The motions of the vernier engines about two axes control the missile attitude around its three axes.

The gimbaling system of the vernier engine mounting was a major design problem. Motion was required through large arcs, but no flexible hose was available, capable of conveying the propellants under the operating conditions. Therefore, it was decided that LOX and RP-1 be fed into the vernier engine through its gimbal elements. The problem was solved by providing orifices in the basic torque-shaft of the "universal joint."

The orifice locations are separated by seals and the shaft surrounded by a housing, thereby creating a series of chambers for LOX, RP-1 fuel, and hydraulic fluid used for actuating the gimbaling system.

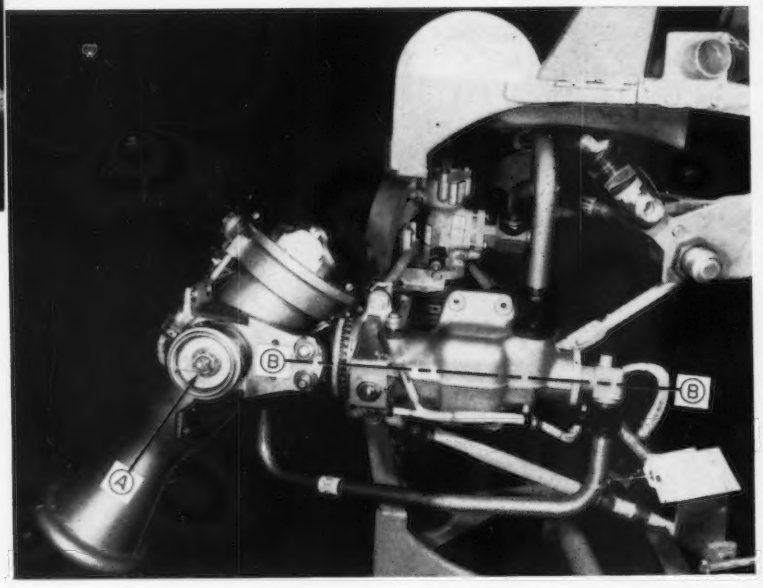
The development of a seal to keep LOX and RP-1 separate prior to ignition became another tough problem. The multi-land seal now used is made of Teflon, preferred for the purpose because of its resistance to low-temperature conditions. Shortly after the engine is started, the seals expand to positively prohibit leakage of fluids or gases across them. Additional safety is provided by locating the opening in the housing for the hydraulic actuator control-rod between the LOX and RP-1 chambers. The actuator opening in the housing is exposed to the atmosphere, to dissipate any leaking fluids or gases from the LOX and RP-1 chambers.

The vernier engine system is a duplicate in miniature of the main rocket engine system; its separate LOX and RP-1 supplies are carried in "solotanks" pressurized by inert gas (nitrogen or helium, varying with different missiles). Each



Top view of vernier engine reveals protective asbestos-phenolic jackets on exposed upstream surfaces. A-A is trunnion axis, and B-B the horizontal torque-axis.

Vernier engine in approximate mounting attitude. Trunnion-mounted thrust chamber can swing about axis A, toward or away from missile body. Axis B-B (of horizontal torque shaft) allows swiveling of trunnion assembly.



vernier engines... continued

motor is ignited by an individual ignition squib, and its duration is independent of main engine starting and stopping. Only element common to both vernier and main engine systems is the turbo pump (A&MM, June 1958, pg. 32), which provides pumping for both propellant systems in flight.

Operational procedure calls for starting the vernier engines first. This is accomplished by energizing the pyrotechnic squib in each vernier engine nozzle. This melts a small wire and activates a solenoid valve. Motion of solenoid opens the pneumatic valve which controls the flow of propellants to the vernier engines. The resulting combustion blows the ignition squibs out of the nozzles. After the vernier engines start, a static-pressure switch automatically begins the main and/or booster engine starting procedure. Following main booster engine start, the vernier engines are fed from the main propellant-tanks through actions of a simple pressure-switch. Simultaneously, the vernier engine solotanks are re-pressurized automatically to place them in readiness for operation after main-engine burnout.

The Rocketdyne vernier engine thrust chamber utilizes the same regenerative cooling principle as the main engine. Fuel passages within the double walls of the vernier engine thrust chamber are created by brazing copper wire to the inner chamber in a helical path. Both walls are of spin-formed 4130 steel. After spin forming, outer wall is split lengthwise and welded onto inner wall. This method of assembly provides an accurate fit between inner and outer walls of combustion chamber. Upper and lower fuel-manifold

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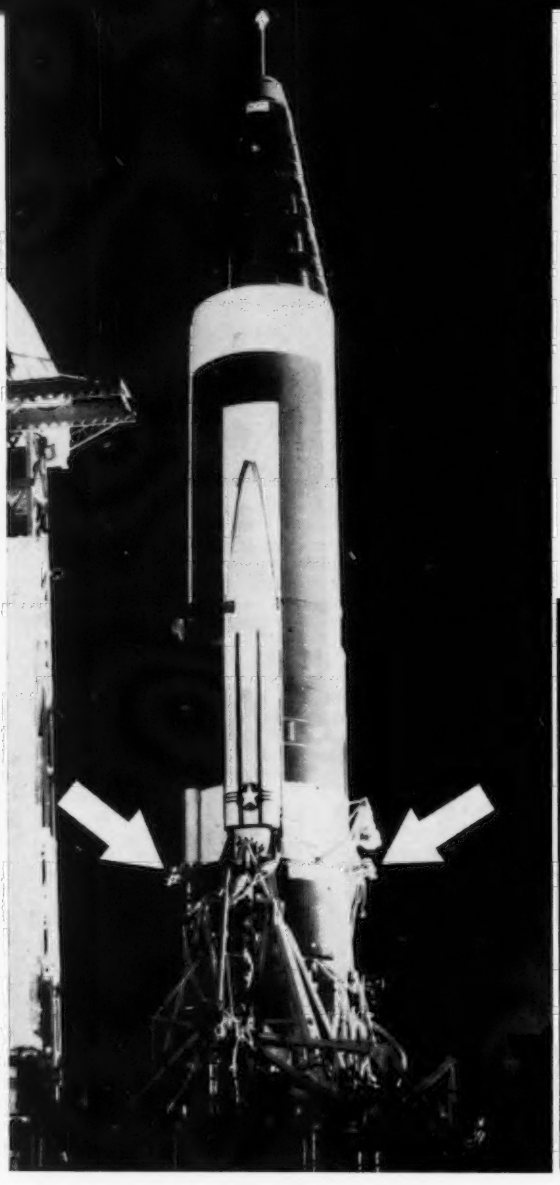
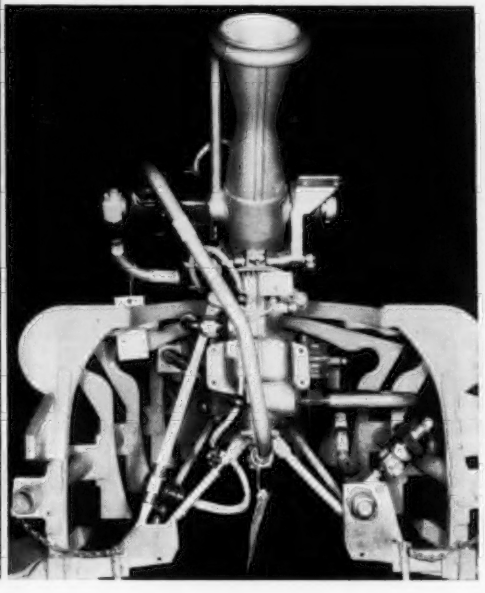


Air Force Atlas stands spotlighted on launching pad at Cape Canaveral.

Bottom view of vernier engine shows details of welded thrust-chamber assembly.



sections are then welded on each end, and the thrust chamber completed.

The main gimbal-shaft is machined from a 4340 steel forged bar, and nickel-plated for resistance to the corrosive propellants. The yoke of the gimbal is machined from 32B aluminum casting alloy, developed by North American Aviation, Los Angeles Division. This high-strength alloy, produced under license, is finding increasing high-temperature applications in aircraft and missile design. The main-shaft housing which constitutes the fluid chambers about the shaft, is a 7075-T6 aluminum alloy die forging. The engine mount, which ties the vernier engine to the missile bulkhead, is of welded 4130 steel tubing.

The Convair Atlas installation locates the vernier engines completely on the exterior of the airframe, exposing them to the severe friction heating of the atmosphere. For this installation, Rocketdyne engineers developed heat-resistant jackets for the upstream surfaces of the system. These jackets are formed from asbestos-phenolic fiber, set with a silicone resin.

Motion of the vernier engine about its two axes is provided by hydraulically-operated actuators servo-controlled from the missile guidance and control system.

In each pair of vernier engines constant thrust is maintained through a simple dividing-tee connection in the propellant lines, one side of which contains a precision pressure-control valve. The back-pressure from either engine reduces the flow to the engine producing the excess of pressure. Each engine contains calibrated orifices to keep its thrust within specification.

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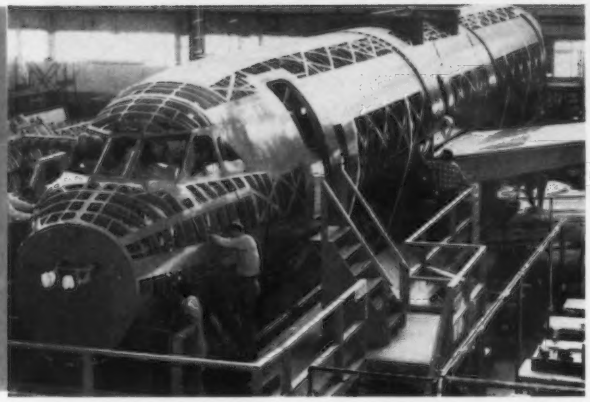
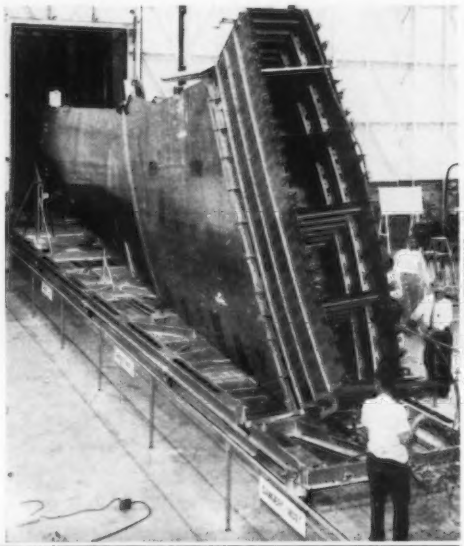
tool-up for Convair 880



All metal replica of Convair 880 is used as part of tooling program. "Master model" is used to establish exact location of electrical wiring, tubing, and cables. Tooling for 615 mph jet includes triplicate set of major tooling fixtures. Roll-out is scheduled for early 1959. Production rate will hit six per month by June 1960.

Forward section of first 880 has left assembly fixture and is being placed on holding cradle for final assembly. First five ships are moving down production line at San Diego.



Swept wings of Convair 880 are fabricated largely by Scotchweld adhesive bonding. Half wings are assembled in huge wing bucks (AMM, Jan. 1958) and then baked in an oven at 320° F to cure the adhesive.

As wing halves emerge from oven they are mated to the 120 ft final span. Still to be added are leading edge, trailing edge, fuselage fillet, and tip. Wing contains eight integral fuel tanks which have a total capacity of 10,770 gal.

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Transportation: Rail and highway facilities are available to these installations, including intra-plant rail and road systems.

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Detailed information, arrangements for inspections, invitations for proposals and sample form of lease may be obtained from the U. S. Army Division Engineer having jurisdiction over the area in which you are interested. The addresses of the Divisions Engineers are:

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CORPS OF ENGINEERS, U.S. ARMY

Circle 121 on Inquiry Card, page 81

missile gaging

checking dimensional relationships rather than simple dimensions required in critical areas

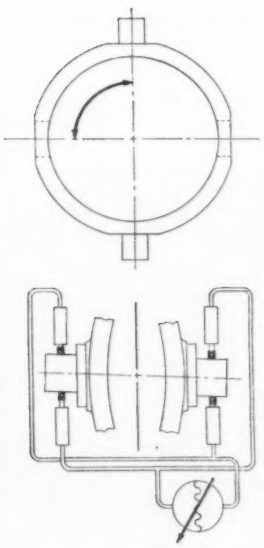
Missile production, generally speaking, is much like regular metal working production in that the required gaging involves a wide variety of dimensions and a wide range of tolerances.

Missile production is unique, however, in several respects. First, many of the parts produced must have dimensional conformance to extremely close tolerances. Secondly, many of the critical gaging jobs involve the checking of dimensional relationships, rather than simple dimensions. Design-wise, gages for this work require special consideration and are of special interest to special users.

Gaging designs range all the way from modifications of stock model gages to complete designs of special purpose automatics, depending on the extent of a company's participation in a missile program. Where problems are considerable, specialists must be called upon to work out the entire gaging program, determining the proper gages for all stages of production from roughing operations through final inspection.

Large concerns like Federal Products Inc. have established a firm grip on the missile gaging projects. This is because they are in a position to furnish counselling service to weapons system firms by virtue of the fact that they produce all types of dimensional indicating gages: dial indicator, air, electric, and electronic. They can thus impartially recommend the gage best suited to the need.

Some of the instruments illustrated here are typical of the gaging requirements in the missile industry.



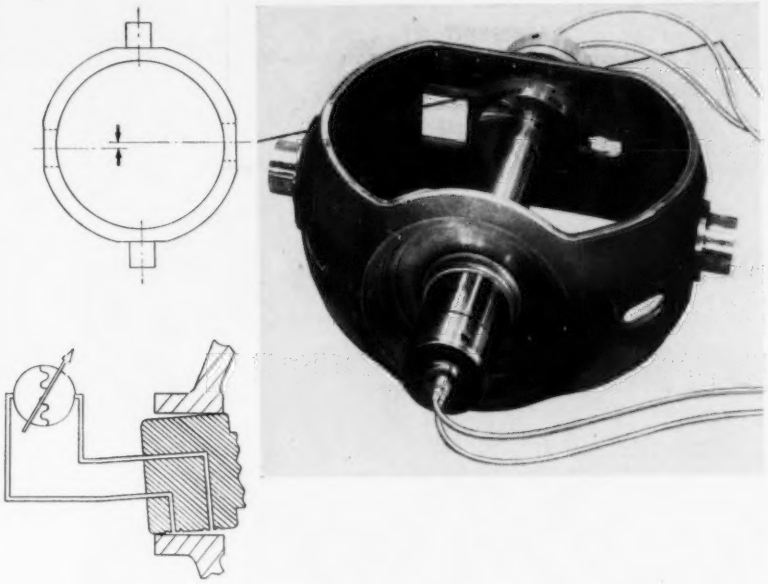
Co-planarity Squareness-Thor

Air gage and cradle fixture checks squareness of pivot axis to bore axis in Thor guidance system gimbal. Precision mandrel, resting in V-block, establishes bore axis. Air Probe gaging contacts, engaging pivots, are cross-paired (as shown in diagram) and connected to opposite sides of air meter. If the two axes are not at 90 deg, pivots will be canted (as shown), shifting each pair of contacts oppositely from the nominal (zero) position. Indicating meter will show unbalance caused by shift. Tolerance is ±0.0005 in. in 20 in.

Alignment-Thor Guidance Gimbal

Mandrel type air plug, working into balanced air meter, checks axial alignment of bores in guidance gimbal of surface-to-air missile.

Any misalignment between bores causes mandrel to take canted position within bore (see diagram) so that air jets are at unequal distances from bore face. Resultant difference in opposed pressures through jets causes unbalance in meter shifting indicating hand from zero (master) position. Plug is rotated so amount and axis of misalignment can be determined. Tolerance is 0.0002 in T.I.R.

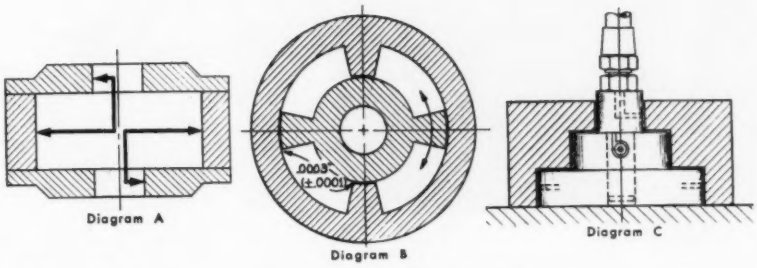


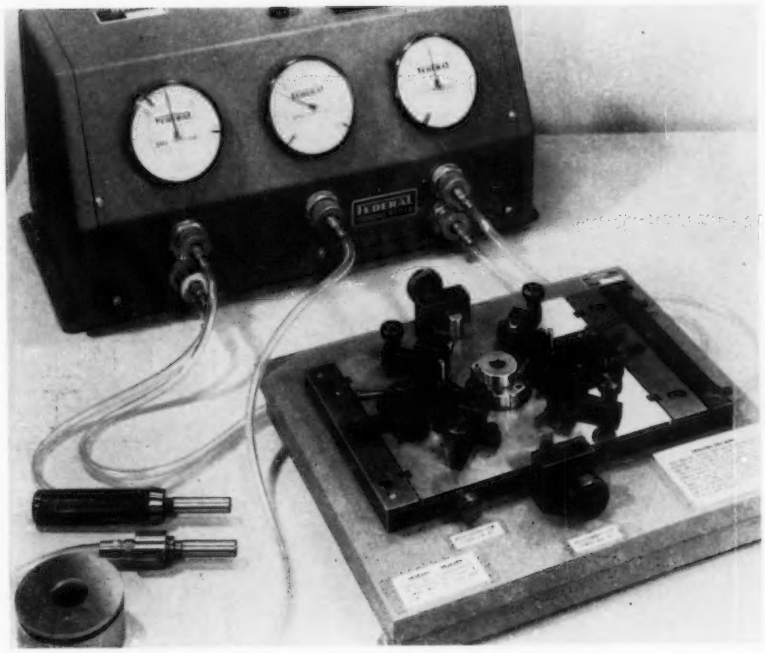
Flight Control Actuator-Bomarc

Triple unit Dimensioner and special fixture serve as high magnification positioning indicator so that end plates and cylinder of missile flight control actuator can be assembled with extreme accuracy. End plate bearing diameters must be positioned so that vaned rotor will maintain 0.0003 in. (±0.0001 in.) clearance with cylinder wall throughout 150 deg arc of travel (diagram B).

Stepped master ring and single jet air plug are placed on fixture, as shown in diagram C. Master is centered in two planes by means of fine adjustment screws at sides of plate. Final position is indicated by zero readings on center dial with plug indexed to each of four positions 90 deg apart. Adjustable dials on outer meters are then zeroed to the readings obtained.

After removal of master, cylinder is located and positioned by means of fine adjustment screws so that readings on outer dials return to zero. End plate is then placed on cylinder and roughly positioned by inserting fixed taper plug in hole of dual air plug. After





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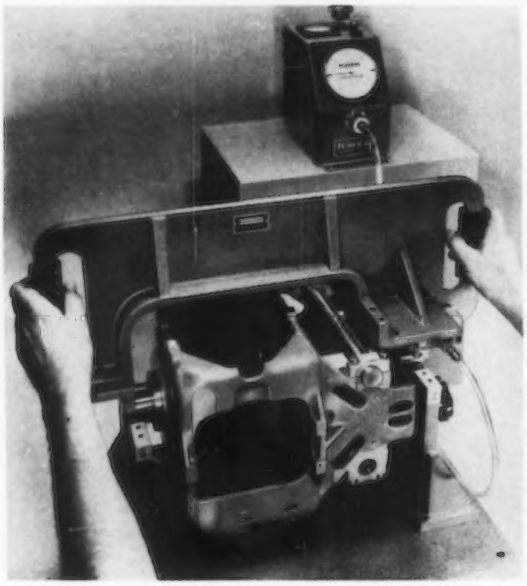
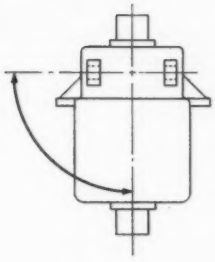
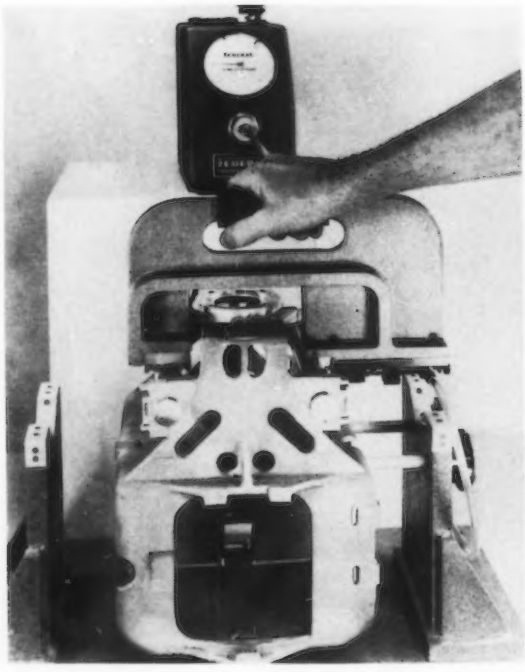
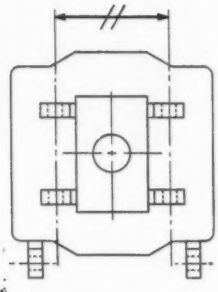
missile gaging . . . continued









fixed plug is removed, portable air plug is re-inserted and swept around bearing diameter of end plate. Radially located fine adjustment screws are used to position plate until sweep of air plug indicates no perceptible variation in position of indicating hand on center dial.

Gimbaled Gyro Platform-Squareness

Portable fixture checks squareness between pivot axis of gimbal platform and axis of bore in which mounting rod of gyroscope will locate. Fixture locates on pivots by means of V-blocks. A precision mandrel establishes bore axis. L-block contact in "C" frame engages mandrel at rear to position fixture. Position of contact plunger in AirProbe determines squareness. AirProbe's restriction to flow of air varies with position of plunger. Resulting change in air pressure within meter is presented on dial in terms of dimensional change with each graduation equal to 0.00005 in. Gimbal platform is held in special cradle equipped with nylon V-surfaces to protect finish of pivots. Tolerance is ±0.0005 in. in 20-in. length.

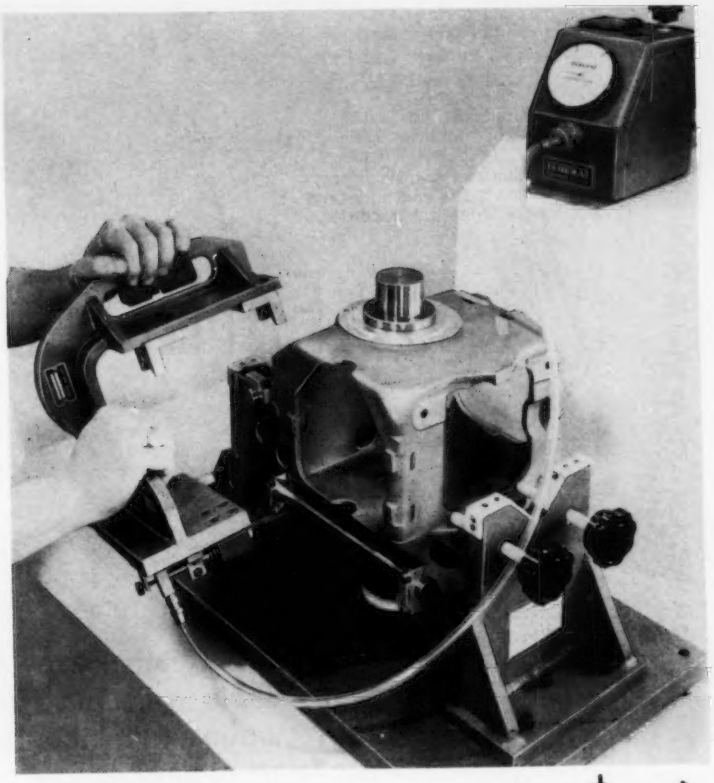
Gimbaled Gyro Platform-Parallelism

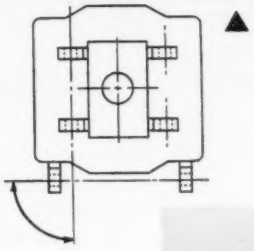
Air gage and C-frame fixture check the co-planar parallelism between two gyro mounting rod bores of gimbal platform. Precision mandrels are fitted into bores to establish axes. Fixture references by means of V-block on mandrel at left. Spacing between mandrels is determined by AirProbe contact at right of C-frame. Measurement is made at two points (near ends of mandrels). Readings within ±0.0001 in. of nominal at either end indicated acceptable condition. Nylon fingers from cradle help position platform.

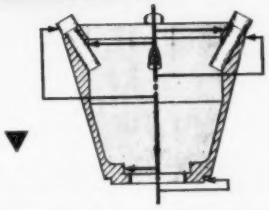
Gimbaled Gyro Platform-Squareness

One of three gyro-mounting rods on guidance platform must be at 90 deg with the other two which are parallel within ±0.0001 in. Gage and fixture check squareness of bores in which these rods will locate. Check is made against only one of the two parallel bore axes and relationship with the other calculated on basis of parallelism error previously determined by other gaging. Mandrels are inserted in bores prior to gaging. Squareness tolerances is ±0.0005 in. in 20 in.

Right angle gaging frame references in one plane by means of V-block locators having cylindrical inserts. Reference in plane of measurement is established by fixed cylindrical contact (not visible). Sensitive contact plunger when in contact with mandrel, bears in against AirProbe contact which transmits variations to Dimensionair graduated in 0.00005 in. Platform is cradled in special holding fixture having nylon collar and V-block inserts to preserve finish of machined surfaces.

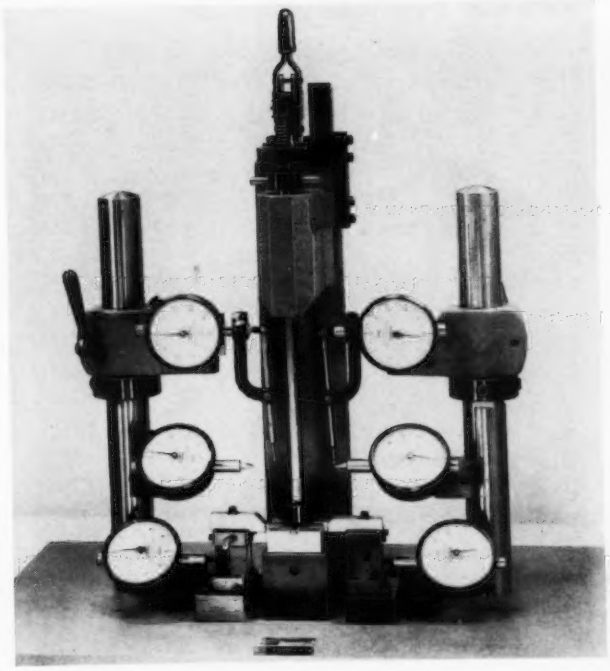


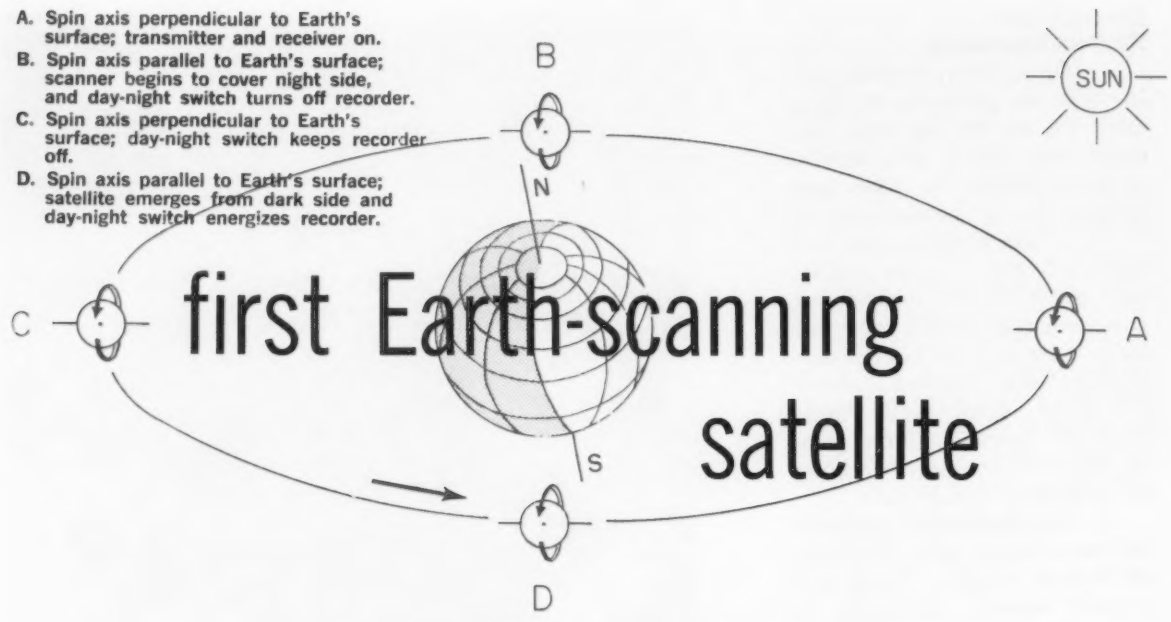




Nose Cone Concentricity-Sparrow

Multi-dimension dial indicator gage makes seven simultaneous concentricity checks on nose cone section of small missile. After part is placed in gage, clamp is lowered to position shown, locating reference diameter of part on three-strip centralizing plug and seating reference shoulder against platen. Part is rotated to get total indicator readings. Tolerance for all O.D.'s is 0.001 in. I. D. tolerances vary from 0.001 in. to 0.010 in. Precision pins are inserted in holes at top of section so datum concentricity of centerlines can be determined. Post-mounted indicators are lifted off locating pins and swung out of the way to facilitate loading and unloading of part. ✦




A. Spin axis perpendicular to Earth's surface; transmitter and receiver on.
B. Spin axis parallel to Earth's surface; scanner begins to cover night side, and day-night switch turns off recorder.
C. Spin axis perpendicular to Earth's surface; day-night switch keeps recorder off.
D. Spin axis parallel to Earth's surface; satellite emerges from dark side and day-night switch energizes recorder.
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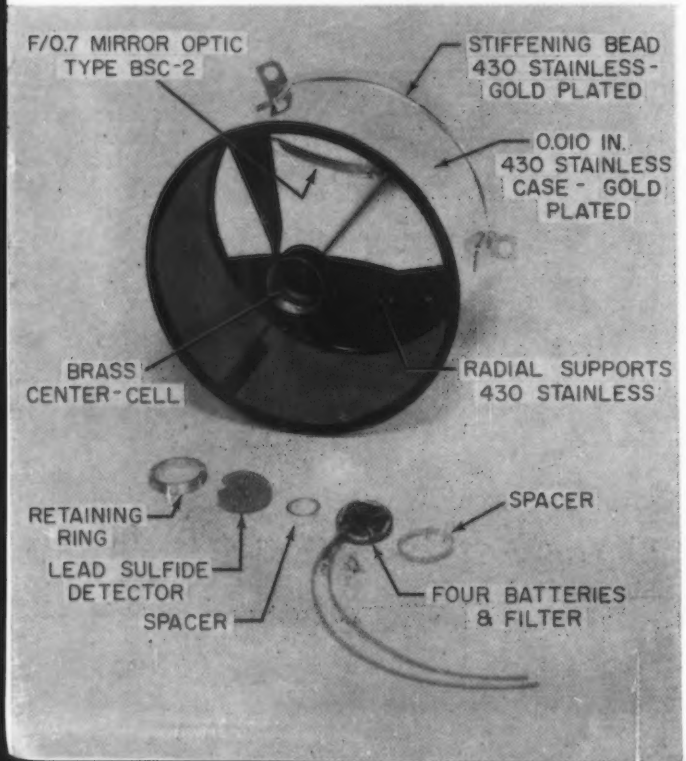
first Earth-scanning satellite

Vanguard "weather eye" signals translatable to visual picture of earth's cloud coverage; mirror optic and miniaturized recording-transmitter are heart of device

by John P. Kushnerick and S. Peter Kaprielyan

Light-detection system in scanner-satellite is an F/0.7 mirror optic focusing on lead sulfide grid. Housing has a 3½ in. diam and is made of gold plated stainless steel.



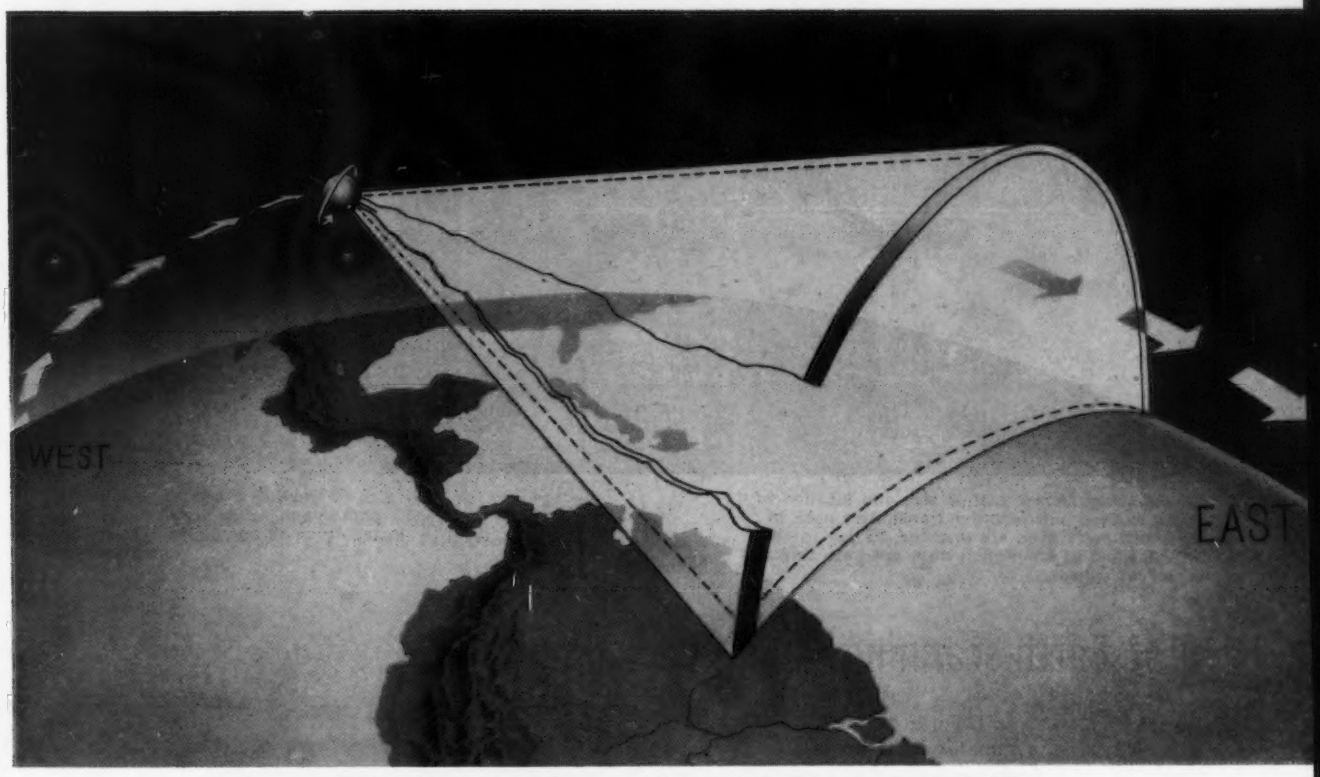
Two small "light-gathering eyes" and their related instrumentation are scheduled to make the next Vanguard satellite a weather scanning vehicle capable of mapping vast areas of the Earth's cloud coverage between 35 deg north and 35 deg south latitudes.

Varying amounts of Earth's reflected light, in the 0.6 to 0.8 micron band, are collected by an F/0.7 mirror optic and focused on a lead sulfide element. Electrical impulses generated from light variations on the lead sulfide element are stored on tape and transmitted back to Earth once in each orbit, on command from a Minitrack station. Oscillatory amplitudes are translated to a black and white TV type visual screen after they are received.

Instrumentation-Operation

Size and weight limitations of IGY satellites have required that "Weather Eye" be kept small, light, and simple in operation.

Designed by the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, with special optics built by Perkin-Elmer Corp., the system is rigidly mounted in the satel-



Weather Eyes canted 45 deg. to spin axis create a conical sweep as scanner-satellite rotates once each sec. Each eye has a scan of 1 deg., this results in band varying from 6 to 50 mi. in width as each eye scans Earth. For purposes of simplification, proportions have been distorted. The conical scan of only one eye is illustrated; second eye would scan rearward in similar pattern.

lite. The recording and telemetering package consists of seven basic units which forms a 5½x13-in. cylinder along the spin axis of the sphere.

Scanning is achieved by rotating the satellite one revolution per second. The spinning satellite functions as a gyroscope, therefore attitude of the spin axis remains constant in space throughout the orbit. Hence, as the satellite revolves around Earth, spin axis is successively parallel and perpendicular to Earth's surface between apogee and perigee.

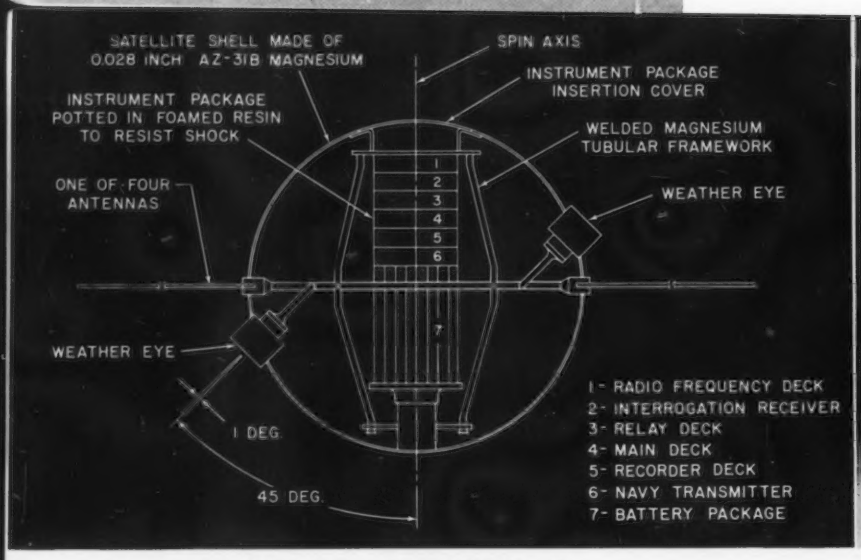
The Weather Eyes are mounted on the periphery of the sphere in such a way that each looks out 45 deg to the axis of rotation. That is, one eye is approximately at the 2 o'clock position, and the other at the 8 o'clock position relative to the spin axis. As the satellite spins, the field of view of each eye sweeps out in the shape of a cone; part of the sweep is out into dark space and part is across the Earth's surface. The coverage of each sweep on the Earth is the arc formed by the intersection of one wall of a thin-walled cone and a sphere. One eye sweeps below and forward, the other eye sweeps below and rearward during the second half of each rotation.

Each eye has a beam width of 1 deg; the distance subtended on earth by this arc is about 6 mi, if the eye is looking straight down from an altitude of 300 mi; the distance subtended on the horizon is about 50 mi. The total horizon to horizon sweep of the eyes is about 2500 mi, but in assembling cloud data, only information from points on the arc that are 300 mi left and right of the satellite path are used. Distortion and line of sight are too oblique at greater distances to create a balanced picture.

With the eyes arranged in this manner they will sweep some portion of earth as long as the apogee is not greater than 1700 mi. At greater distances the 45 deg mounting would cause the 1 degree beam to miss the horizon and look into space during certain orientations of the spin axis. At no time is it possible for both eyes to scan the Earth simultaneously. This allows the use of a single transmitting channel.

Not Infrared

Misconception about the satellite's operation and function have grown from certain references to it as an infrared device. The instrument



Line drawing shows relative size and location of Weather Eyes and recorder transmitter pack in 20-in. sphere. Eyes are oriented 45 deg to spin axis but line of orientation does not pass through center of sphere.

Size of Weather Eye is apparent from photograph which shows technician installing small components in central brass-housing.

first Earth-scanning satellite . . . continued

is greatly dependent on visible light for its operation. The 0.6 to 0.8 micron band used dips into infrared slightly; however, choice of this band was influenced primarily because it represents a minimum interference range in the visible spectrum. A day-night switch turns off recorder and transmitter while the satellite passes over the dark side of Earth. This is to conserve battery power.

The heart of the light-gathering system is a fast F/0.7 mirror optical-system which focuses light energy onto a sensitive 1 mm square Ektron lead sulfide detector. Light is filtered before generating impulses on the recording tape. Despite the high degree of light gathering power, each eye weighs only 3½ oz. The tiny magnetic tape-recorder located near the center of the cylindrical instrumentation package, represents a near ultimate in miniaturization. The unit handles 75 ft of ¼-in. tape at recording speeds of about 0.31 in. per sec. Maximum recording time is approximately 50 min, or half of one revolution around Earth. Since the day-night switch turns off the mechanism while satellite is on the dark half of the Earth, this recording time is sufficient. The stored data is played back in about 1 min on command from the Minitrack station. Minitrack stations used form a "picket line" extending from southern U. S. to South America.

The shapes and amplitudes of the signals received depend on the intensities of reflected light from the various areas viewed. Intensities vary appreciably: 80 per cent reflectivity from cloud areas, 20 per cent from land areas and less than 10 per cent from sea areas. Thus, cloud, land, and sea can easily be distinguished.

Materials of Construction

Shell of the Weather Eyes is constructed of 0.010-in. 430 stainless steel. Stiffening beads of the same material are added at each end of the butt welded 3½-in. cylinder. Mirror is of Type BSC-2 mirror-glass, bonded in place with Pliobond. One important reason for selecting this glass and 430 stainless is their compatibility in thermal expansion.

Radial ribs of the cell are also 0.010-in. stainless, spot welded to the main cell, and silver soldered to the center brass detector-cell. The Weather Eye metallic structure is gold plated to match satellite-shell coating. Heat exchange between the two surfaces are thus minimized.

Impact

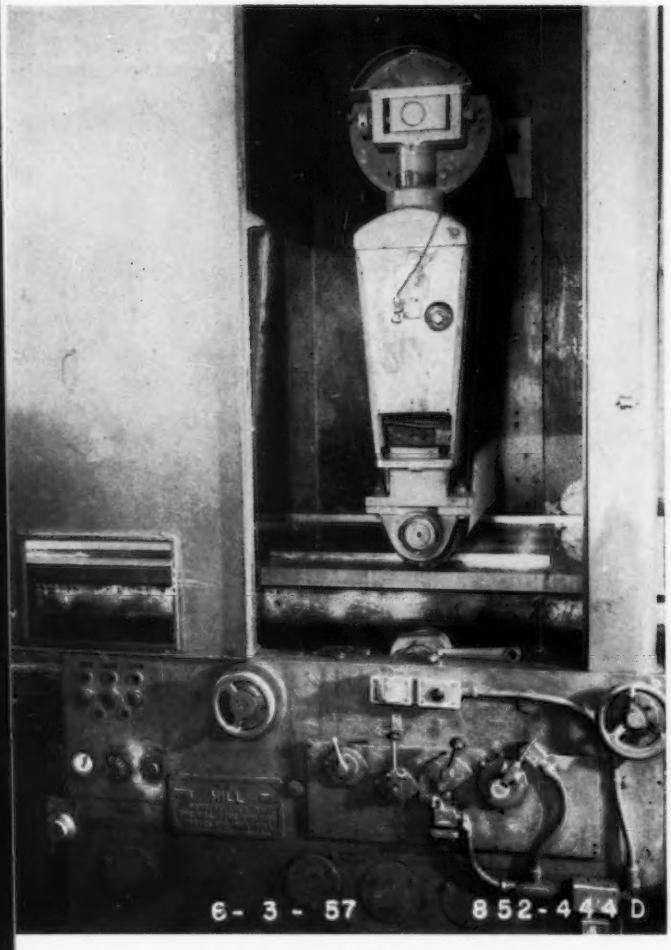
Less than 5 per cent of the Earth's surface is covered by accurate meteorological observation stations. Observing the world's cloud-cover formation has long been a dream of meteorologists, since these data can be translated into long-range forecast of violent storms and hurricanes. Weather Eye is only a small contribution to forecasting and tracking, but follow-on systems could revolutionize meteorology.

✦

precision-sizing sheet stock

weight saving and improved surface conditions advantages of finishing loose-tolerance stock; belt grinders prove effective

by **Paul Queyrel**, president, Mill Polishing Corp.



Grinding 17-4 stainless plate (24x72 in.) to 1.000 in. plus 0.003 minus 0.600 in. using solid table-base on machine.

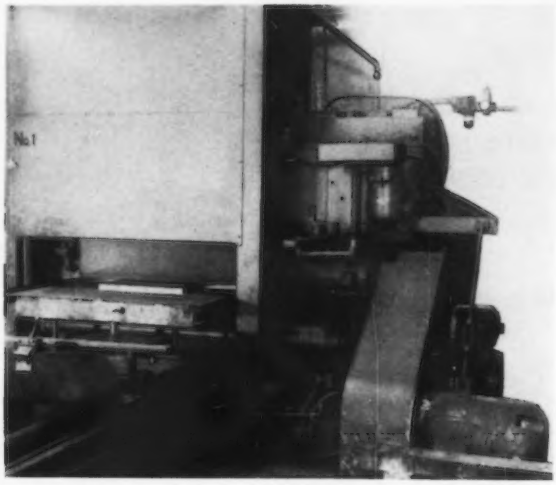
Sheet sizing, the grinding of loose-tolerance mill-delivered sheet to precision thickness, has become a major weapon in the aircraft and missile designer's battle against weight. The process is also providing stress relief, reduced drag and improved chemical milling properties.

Pioneering the quantity production of precision-sized sheet is Mill Polishing Corp., Huntington Park, Calif., which is providing the aircraft and missile manufacturing industry with sheets finished within 0.001 in. of required thickness. Also, by this process, skins which would have been ejected before, are now being salvaged on an assembly-line basis. The success of mill polishing is based on the recognition of the practical limits of accuracy attainable by the rolling mills. Aluminum alloy sheet is delivered to aircraft and missile manufacturers with a ± 5 per cent thickness tolerance. Magnesium is provided with a ± 7 per cent tolerance, stainless steel with a ± 10 per cent, and titanium in excess of ± 10 per cent with wide variations.

These loose limits mean, for example, that the missile manufacturer must purchase 0.110-in. sheet in order to have a minimum 0.100-in. stainless steel skin. The sheets upon arrival may measure as thick as 0.120-in. resulting in as much as 34 lb of excess material in a typical 48 x 120-in. sheet. Mill Polishing Corp. grinds this sheet to 0.102 in. ± 0.002, reducing the excess weight to

precision-sizing sheet stock...

continued



Overall view of Hill Acme machine used for sheet sizing.

6.8 lb per sheet. The value of this weight saving (sometimes computed as high as $1,000/lb in a missile) makes the cost of its removal relatively insignificant.

Sheet sizing is accomplished at Mill Polishing Corp. by two types of Hill Acme grinding machines. One of these is the conventional abrasive-belt machine utilizing a planer table, reciprocating beneath a contact roll with an abrasive belt the full width of the sheet. The other type uses sets of pinch rolls to feed the sheet to the grinding head, where it passes between an abrasive belt and a pressure roll. Another set of pinch rolls then carries the sheet out the other side of the machine. The machines are equipped with special contact-roll dressing devices, and have means of controlling the feed speeds and pressures. A coolant is applied sparingly, as most high-density alloys grind more efficiently at 150-200°F. This grinding process tends to remove surface tensions and generally produce a stress-relieved condition.

The firm is currently accepting orders on materials up to five ft wide by 20 ft long, and in a thickness range of 0.025 to 0.150 in. They are anticipating extending this range from 0.008 to 3.000 in. Inconel "X," a difficult material to

Taper grinding T-410 stainless disk to be drawn later into high-pressure tank ends.

Checking gage thickness at predetermined inspection points.

work, has been ground from a 0.025-in. thickness to 0.0135 ± 0.0005 in.

Belt abrasive varies with the metal to be ground. The paper-back belts used for titanium and aluminum are coated with silicon carbide, a hard and brittle abrasive. An aluminum-oxide coated belt is used for stainless steel. The belts run on Neoprene rolls. Mill Polishing Corp. cuts its own contact rolls in spiral serrations, which increase the cutting qualities as much as 50 per cent over plain rolls.

Sheet-feed speeds vary from 20 to 80 ft/min; belt speed rate is 4000 ft/min for stainless steel, and 6000 ft/min for aluminum alloy. The resulting high relative-velocity between belt and sheet generates temperatures of 140-150°F; an essential to the grinding operation. On some materials this produces an actual flame-front along the contact line.

The severity of the grinding process on the thin, soft sheets is reduced by making numerous passes through the grinder. For example, aluminum is removed at a maximum cut of 0.0025 in./pass, stainless steel at 0.0005 in./pass and magnesium at 0.005 in./pass. Titanium is removed at the rate of only 0.00003 in./pass. The multiple-pass approach permits grinding of scratches and imperfections out of Alclad. In this case the clad coating of about 0.005 in. of pure aluminum is reduced 0.002 in., without decreasing the corrosion protection.

Chemical milling accuracy is greatly increased by first sizing the sheet to remove surface defects, such as inclusions, laminations and handling scores. Such pre-finishing produces perfectly flat etched surfaces.

Techniques have also been perfected for the grinding of multi-tapered sheets, and even the grinding of conical taper in a circular missile tank end-blank.

Following grinding, the 30 micro-inch finish of sheets (mirror finish of 5-10 micro-inch is regularly produced by buffing) is protected by a vinyl plastic coating applied by an automatic-spray machine. This uniform coating can easily be stripped off later. A heavier, more durable pressure-sensitive adhesive-paper coating is used when sheets are to be stacked for storage. Both of these coatings protect the sheets during press forming, yet contain no waxes to come off on dies.

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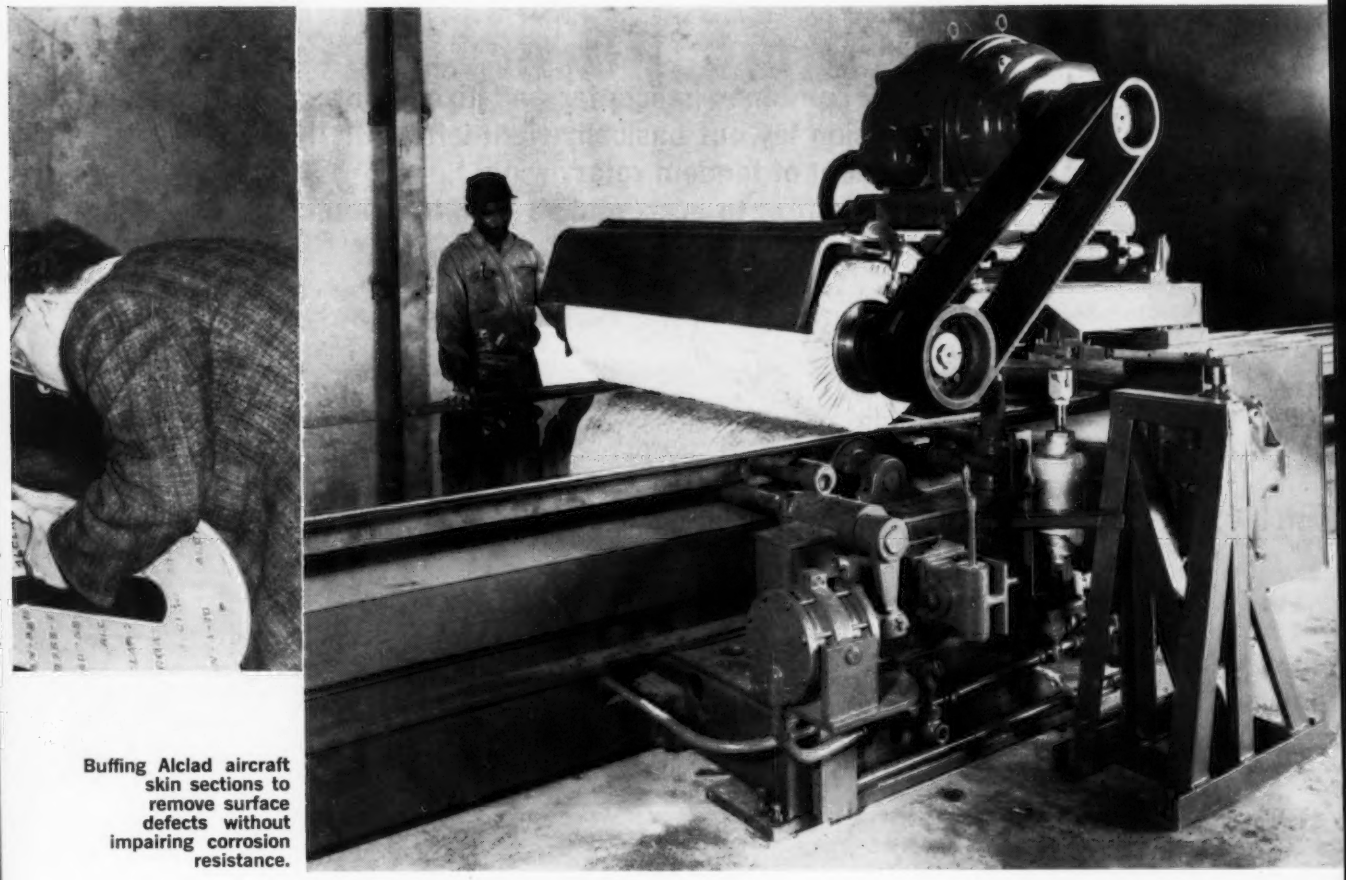


Buffing Alclad aircraft skin sections to remove surface defects without impairing corrosion resistance.

Early photograph shows Vertol 76 in hovering flight. Slight modifications have been made: oleo tail wheel vs. spring type support shown, and masked out area on front of bubble to provide pilot with horizontal reference. Testbed made first full transition in late July.

tilt-wing VTOL

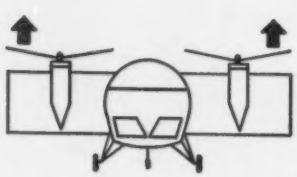
Vertol 76 combines helicopter and fixed wing control concepts, transmission lay out basically right-left arrangement of tandem rotary wing; test vehicle first to acccomplish "full transition"

by John P. Kushnerick

VERTICAL FLIGHT

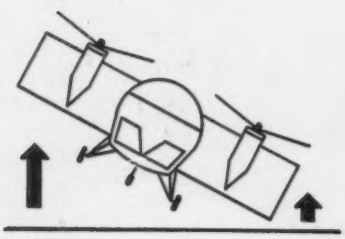
HOVER FLIGHT

Collective pitch equally and simultaneously varies rotor-prop pitch for vertical ascent.



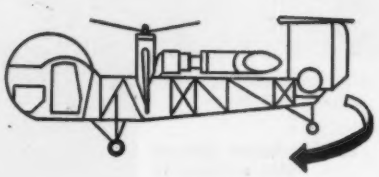
ROLL CONTROL

Differential pitch varies rotor-prop pitch individually to rotate aircraft about longitudinal axis.



YAW CONTROL

Controllable-pitch fan mounted in lower portion of vertical tail controls yaw.



A scantily clad airframe of welded 4130 steel; a nose canopy from a competitor's production aircraft; landing gear from an HUP model tandem helicopter; a derated Lycoming T-53 driving two 9½ ft rotor-propellers and two ducted fans; a 24 ft 11 in. wing that tilts through 90 deg; thousands of engineering man-hours; and about 1.5 million dollars in development funds; these comprise the Vertol 76—a flying test bed making aviation history with its vertical ascents, conventional aircraft passes, and vertical descents at Philadelphia International Airport.

Funded by Army as the VZ-2 and developed under cognizance of Office of Naval Research, the 76 is the first aircraft to successfully demonstrate the turboprop tilt-wing VTOL (Vertical-Takeoff and Landing) principle.

Hopes are high in vertical lift circles that this flying testbed will open vast new areas for expansion of a market up to now dominated by helicopters. Cruise speeds in the 350 to 450 mph range are envisioned for the tilt-wing VTOL.

Vertol was a natural to be first in the air with this configuration since the shafting and transmission layout which drive the twin rotor-props off a single power plant is basically a port and starboard arrangement of the tandem rotor system pioneered in HRP, HUP, and H-21 by Vertol (then Piasecki Aircraft Corp.).

Development of the 76 has been swift, but not without setbacks. Less than one year elapsed between the first flight in August, 1957, and the first complete transition. In the initial hover attempt some flight controls were found to be too sensitive, others too sluggish. Major kinematic changes caused discouraging delays immediately after the first flight.

Controls

Method of achieving positive control in all flight regimes is by varying blade pitch of two ducted fans mounted in the empennage. Fans are each 2 ft in diam, blades are made of laminated birch. One is located in the horizontal tail slab to give pitch control, and one is mounted vertically along the fuselage center line just below the rudder for yaw control. Fans are driven mechanically from the main transmission. Hence, it is hoped control can be maintained in the event of power failure through energy supplied back to the fans by the autorotating main rotors.

Cockpit controls are basically a normal helicopter layout. With the wing tilted perpendicular to the ground, control is achieved as follows:

Vertical ascent or descent, by collective pitch which simultaneously and equally varies the angle of attack of both prop-rotors.

Roll control, by differential pitch which varies angle of attack of prop-rotors separately to raise one wing or the other.

Pitch control, by varying the blade angle on the fan mounted in the horizontal tail slab; yaw control, by varying the blade angle on the fan mounted vertically beneath the rudder.

The collective pitch lever controls collective pitch, rudders control yaw fan, and cyclic stick controls pitch fan. Maximum pitching acceleration by manipulating pilot controls is 1 radian/sec/sec. Maximum yawing acceleration is 0.35 radians/sec/sec. Maximum rolling acceleration is about 2.5 radians/sec/sec.

Transition

Tilting the wing is accomplished by an electromechanical actuator which positions a hydraulic servo system. The tilt system has a variable speed; pilot controls the conversion rate through a spring loaded button mounted on the

PITCH CONTROL

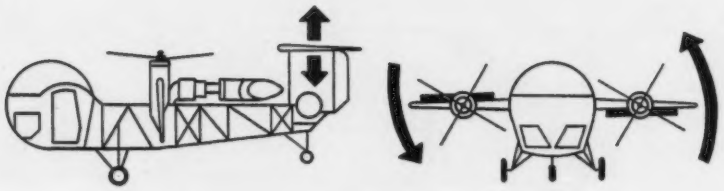
Controllable-pitch fan mounted in horizontal tail slab controls pitch.

ROLL CONTROL

Differential pitch system washes out during transition to aircraft configuration and aileron system cuts in.

YAW AND PITCH CONTROL

Operation and function of yaw and pitch fans does not change in horizontal flight. Fans supplement conventional tail controls when airfoils become effective.



HORIZONTAL FLIGHT

tilt-wing VTOL . . . continued

cyclic stick. When just cracked open the wing tilts at its minimum rate; as button deflection is increased, tilt rate increases. Wing can be adjusted to any position between helicopter and airplane configuration to obtain best STOL (Short Takeoff and Landing) operations. The wing is fixed to the fuselage by two self-aligning bearings. Hydraulic power to tilt the wing is supplied by a gear type pump mounted on the central transmission gear box. Drive shafting to the right and left rotor-props passes through the fuselage hinge points.

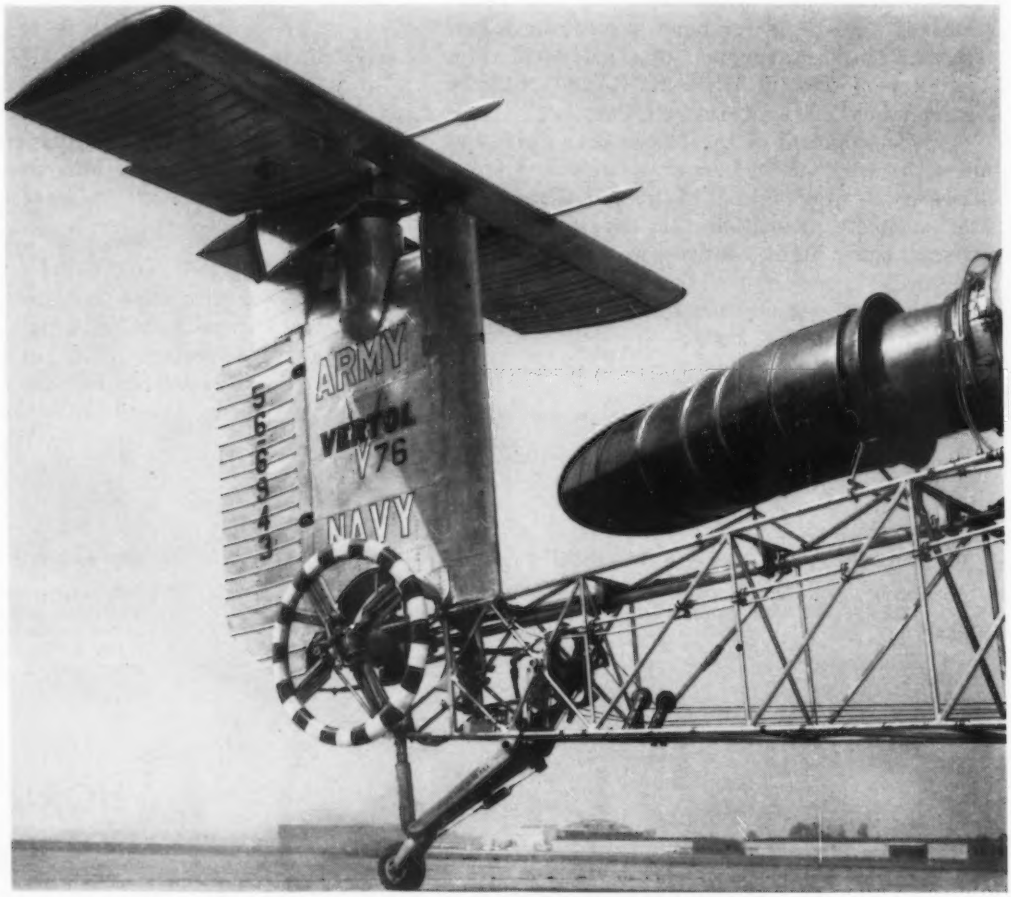
During the conversion from "helicopter" to airplane flight, the lateral (roil) control system converts automatically to airplane controls. The differential collective pitch system washes out gradually while the aileron system cuts in.

The collective pitch lever is not affected by the wing tilt position. It is used as a propeller pitch control after conversion.

The pitch and yaw fans do not change in function or operation in forward flight. They supplement the elevator and rudder respectively. Fans could be phased out, but this has not been done in the interest of simplicity.

Propulsion System

Power from the Lycoming T-53 free turbine engine is distributed by mechanical shafting. Layout is essentially a port and starboard arrangement of the normal tandem helicopter transmission system. Both the rotor-props and tail fans are interconnected mechanically; in the event of engine failure they override the engine through a sprag clutch in the upper central transmission box. The upper central gear box is connected directly to the engine power output as an ordinary turboprop reduction box would be. Drive shafting from right and left sides of the central gear box passes through the fuselage hinge points to gear boxes mounted in each



Yaw fan (in stripped safety guard) and pitch fan mounted in center of horizontal slab, provide pitch and yaw control in vertical flight. Testbed utilizes simple structure and airfoils to keep cost and unknowns at a minimum in proving tilt-wing concept.

wing nacelle.

Shaft speed up to the rotor gear boxes is approximately engine output speed and is reduced to rotor speed at this point. The rotor-props rotate in opposite directions to balance torque.

SPECIFICATIONS FOR VERTOL 76

Span	24 ft. 11 in.
Length	26 ft. 5 in.
Height	10 ft.
Gross Weight	3200 lb.
Wheel Tread	7 ft.
Tail Span	9 ft. 11 in.
Rotor-Prop Diam.	9 ft. 6 in.
Pitch and Yaw	24 in.
Fan Diam.	
Wing Area	11 sq. ft.
Wing Airfoil	NACA 4415

Flight Test Changes

Certain modifications were required to the original configuration as a result of preliminary taxi tests:

- larger rudder area.
- steerable tail wheel.
- oleo-strut in tail gear (replaced spring strut).

With these modifications the aircraft could perform turns from standstill and maintain directional control during takeoff and landing roll-out. New tail gear eliminated pitching motion during vertical takeoff and landing and high speed taxi.

In initial hover flights pilot experienced difficulty establishing straight-and-level attitude. There was an uncomfortable feeling of hovering nose down when aircraft was actually 5 deg nose up. This was due to the wide open bubble-type canopy. The lower area of the bubble was masked out to provide sufficient horizon reference, and the trouble was eliminated.

Taxi and conventional flight tests disclosed that tilting the wing also makes an effective flap for deceleration. Wing is tilted up 3 deg during approach to airplane landing; stops from 90 kt run-on were accomplished in a short distance by tilting wing to vertical position after touch down.

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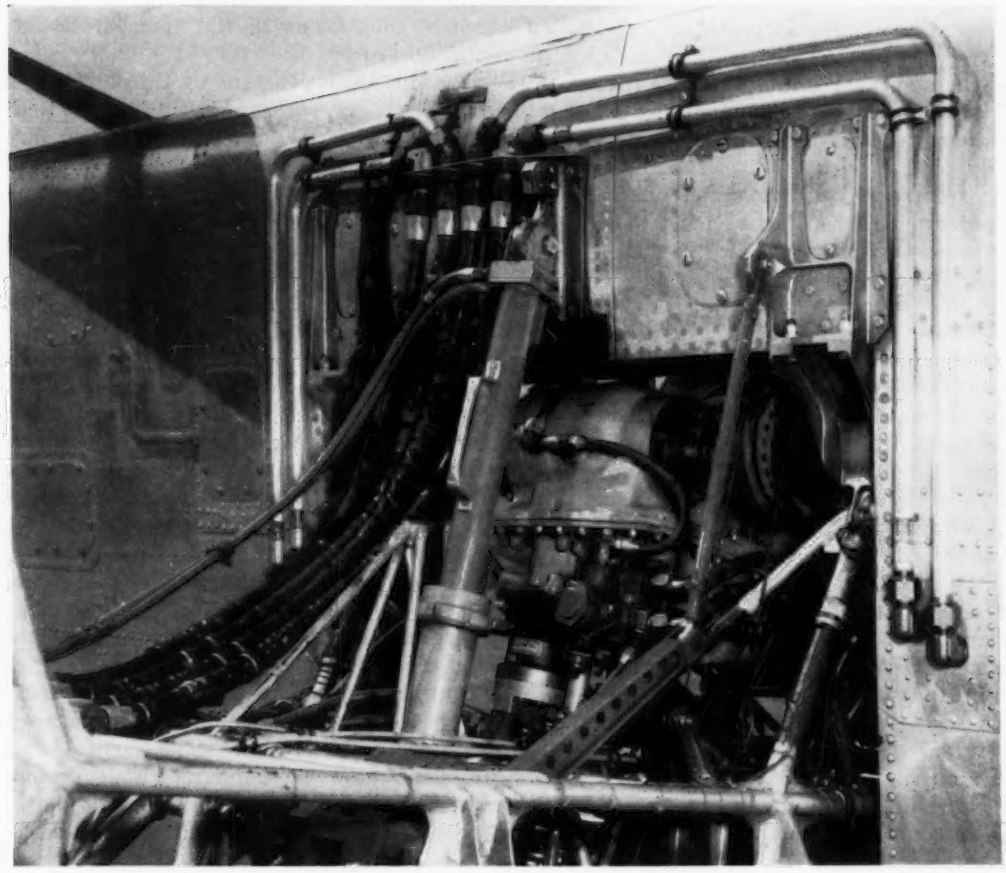
Hydraulic power is used to tilt the wing, main actuator is shown in center of picture. Drive shafting to left and right rotor-props passes through fuselage hinge points.



homogeneous fiber-polymer

Teflon coated ceramic fibers uniformly mixed in water dispersion provide antenna shields for reentry

by N. L. Greenman, Rogers Corp.

The special properties needed in the materials for today's and tomorrow's weapons systems and space vehicles are becoming increasingly difficult to attain.

To obtain these properties may require the use of not only new materials or combinations of basic materials, but processes which have not yet been considered.

Forming from a water dispersion offers challenging opportunities when homogeneity and uniformity are necessary characteristics in fiber-polymer systems.

New Re-entry Material

One of the newest in this series of fiber-reinforced materials is Duroid 5650, a ceramic fiber reinforced Teflon. Duroid 5650 is made by coating ceramic fibers, composed of 50 per cent silica and 50 per cent alumina, with Teflon and then forming these coated fibers into a sheet which is subsequently molded.

Duroid 5650, which has a higher Teflon to fiber ratio than the original fiber reinforced Teflon (Duroid 5600), was intended for use in electrical and electronic applications. As a result of work done at the Diamond Ordnance Fuze Laboratories and the ABMA in Huntsville, it has also been used as a waveguide window at very high temperatures, such as those encountered during the re-entry period of a missile flight.

The following properties are of major importance in the antenna application:

- SIGNAL UNIFORMITY—Transmission of high frequency signals as measured at DOFL is uniform in any direction through the material—an excellent illustration of the homogeneity attained in the process.

The dielectric constant of Duroid 5650 is 2.6, and it has a loss factor of about 0.0018. Both the dielectric constant and loss factor curves are flat from 25 to 280°C in the frequency range of 10^7 to 10^{10} cycles.

- ABLATION—The ceramic fiber slows down the rate of ablation from that of pure Teflon, and the homogeneity and uniformity of the fiber-Teflon structure results in a surface which ablates evenly to produce a smooth surface. Rate of ablation is cut to half that of Teflon when the fibers are oriented normal to the flow of hot gas. Because the Teflon decomposes with no carbon deposit formation, burning, charring, or cracking, there is no signal distortion. Tests at Huntsville exposed Duroid 5650 for up to 11 sec to the direct flame of an 18000 lb thrust engine rocket exhaust 34 in. from the point of discharge. This produced a temperature of 1600°C on the surface of the Duroid 5650. There was substantial ablation, but the ablated surface appeared completely smooth, almost as though it had been machined.

Duroid 5650 can be machined very easily and has been molded directly to shape. One very useful property is the low mold shrink of 3 mils/in. This may be compared with normal Teflon mold shrinkage of about 20 mils/in. to show how the fiber matrix has stabilized the system.

Areas for Improvement

While Duroid 5650 has proven itself a very satisfactory material for the antenna application, two problems remain, ablation rate, and coefficient of thermal expansion.

The ablation rate, although much better than Teflon, must be improved to bring it up to the level of the main nose cone covering. It would also be desirable if the coefficient of thermal expansion in the thickness direction could be lowered for ease of fabrication. This does not now appear to be a basic problem. The coefficient of thermal expansion in the other two planes of Duroid 5650 is much better than Teflon and actually falls within the range of aluminum and some stainless steels.

The following approaches have been tried to improve ablation: (1) In use, the fibers in the Duroid 5650 are normal to the flow of air. More and/or longer fibers should slow the ablation rate. (2) Ceramic fibers with higher melt viscosity may also show an improvement. (3) Previous work in other laboratories has indicated that the ablation rate is affected by the pressure during molding. Materials incorporating these three modifications have been produced and are awaiting test at Huntsville.

As might be expected, the greatest effect on coefficient of thermal expansion in the thickness direction is produced by the addition of more fiber or filler to replace Teflon. In addition, preliminary data indicate that certain very small particle size fillers (1/100 micron) give a greater improvement per unit weight than fibers of the same chemical composition. While the effect of raising or lowering pressure was not significant, interesting preliminary results have been obtained by the use of pressure from two directions, and this work is being continued.

Shaped Preforms

There is one other facet of this method which should be mentioned—the formation of shapes directly from the water dispersion to provide preforms ready for molding. Since the sheet product is restricted in its movement during molding due to its interlocking fiber structure, only very simple shapes can be molded directly from sheet stock. However, shaped preforms would retain the homogeneity of the sheet material and provide a molded structure free of weak spots often encountered in "resin rich" or "resin poor" areas in large reinforced plastic moldings, thus expanding the use of this class of materials to include complex shapes. It should be possible, for example, to form and then mold complete radomes by the proper use of this technique.

Some of the basic characteristics of products made by the water dispersion process, also called beater-addition, are as follows:

- HOMOGENEITY — The beater addition process consists of adding a resin emulsion or dispersion to a dilute suspension of fibers in water, coating the individual fibers with the resin, and then forming a sheet on a paper machine.

Because it is done in an extremely dilute suspension, this method results in a completely homogeneous blend of fiber and resin ready for molding.

- UNIFORMITY—The cylinder wet machine on which this moldable sheet is formed is a wet laminating device. Very thin, uniform plies of fiber and resin are continually being wound on a mandrel and the sheet removed when the desired thickness has been attained. Thus, a molded sheet of 1/16 in. thickness may consist of 40 to 60 laminations, uniform in themselves, which have been bonded together while wet on the mandrel.
- VERSATILITY—The versatility of the beater-addition process results from the ability to produce modifications of resin-fiber blends by the addition of particle fillers or of small amounts of other resins and fibers.
- MACHINING—The fiber structure obtained by this process is easier to machine than fabric saturated materials, since individual fibers rather than bundles of fibers are being machined. Surfaces ground to within two wave bands of helium have been attained with a ceramic fiber reinforced Teflon. No special tools are needed except for carbide tipped cutting edges.

Limitations

A discussion of beater-addition materials would not be complete without pointing out their limitations as compared with the conventional means of manufacturing reinforced plastics. First, and foremost, is the greater strength which can be obtained by the use of woven fabrics and oriented filaments. Where these strengths are necessary, beater-addition materials cannot now provide the answer.

Another, but less serious, drawback is the necessity that the polymers used in the process be dispersible in water. This is not too troublesome, however, since most polymers can either be dispersed or emulsified satisfactorily.

In spite of these limitations, the beater-addition process offers real opportunities in the design of products—with specific properties for specific applications. This has been demonstrated by the Duroid 5600 series.

When the utmost in homogeneity and uniformity are necessary characteristics in fiber-polymer materials, products made from water dispersions certainly merit consideration.

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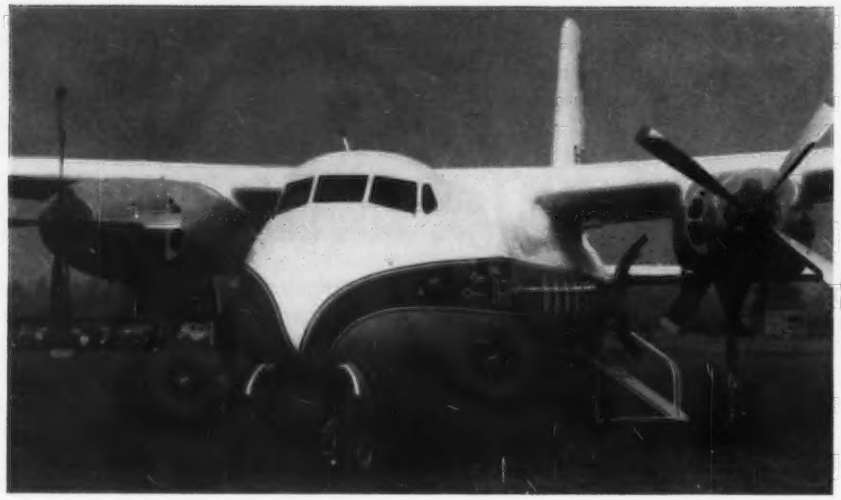
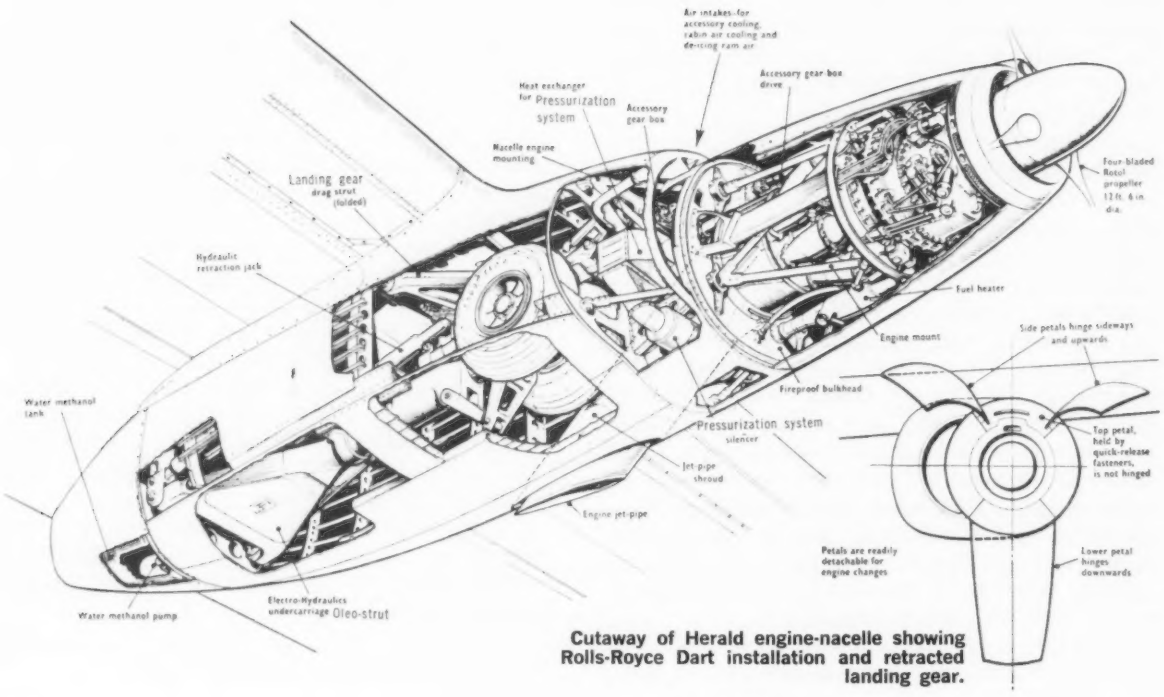


Close-up of Dart-engined Herald shows low loading-height of access doors.

short-haul versatility

Handley Page Herald aims for DC-3 market, offered with two turboprops or four radial powerplants, designed for passenger and/or cargo service

by Ronald A. Cole


Air intakes for accessory cooling, cabin air cooling and de-icing ram air
Accessory gear box drive
Heat exchanger for Pressurization system
Accessory gear box
Nacelle engine mounting
Landing gear drag strut (folded)
Four-bladed Rotol propeller 12 ft. 6 in. dia.
Hydraulic retraction jack
Fuel heater
Engine mount
Side petals hinge sideways and upwards
Fireproof bulkhead
Water methanol tank
Pressurization system silencer
Top petal, held by quick-release fasteners, is not hinged
Jet-pipe shroud
Engine jet-pipe
Petals are readily detachable for engine changes
Lower petal hinges downwards
Water methanol pump
Electro-Hydraulics undercarriage Oleo-strut

Cutaway of Herald engine-nacelle showing Rolls-Royce Dart installation and retracted landing gear.

Designed for passenger and/or cargo service, the Herald is another contender for the DC-3 market.

To suit the varying needs of short-haul operators it can be powered by four radial engines or two turbo-props.

For ruggedness of structure and ease of field maintenance, sandwich skin and conventional construction have been combined. Extensive use of spot-welding has accelerated production and reduced costs. The makers state that the Herald, with two Rolls-Royce Dart turbo-prop engines is available for considerably less than its competitor.

Fuselage Structure

Fuselage cross-sectional shape consists of a circle and a larger lower-arc joined at floor level. Deep "Z"—section floating hoops carry pre-assembled skin-stringer panels. The floor is supported by formed deck-bulkheads with intermittent flanges riveted to lower-fuselage skin. Channel-section stiffeners along fuselage are spot welded to the skin panels. Two heavy channel-section longerons cross the deck bulkheads, and carry anchoring points for seats. Additional attachment points are built into the cabin wall. Seats may be spaced 34½ or 38 in. apart, facing fore or aft. Seats and attachments are designed for 9G deceleration.

Loading-doors 5½ ft wide and 5 ft high allow handling of bulky loads. A separate hatch ahead of the wing allows stowage of smaller loads.

A pair of built-up ring-frames pick up four attachment points on each of the front and rear shear-webs of wing. These frames are designed to bear the wing weight in the event of a belly landing. Only two bulkheads, one separating the flight deck and the other forming the rear pressure-bulkhead, are visible in the cabin. Pressurization level is 3.35 psi, maintaining a cabin altitude of 6500 ft at 15,000 ft.

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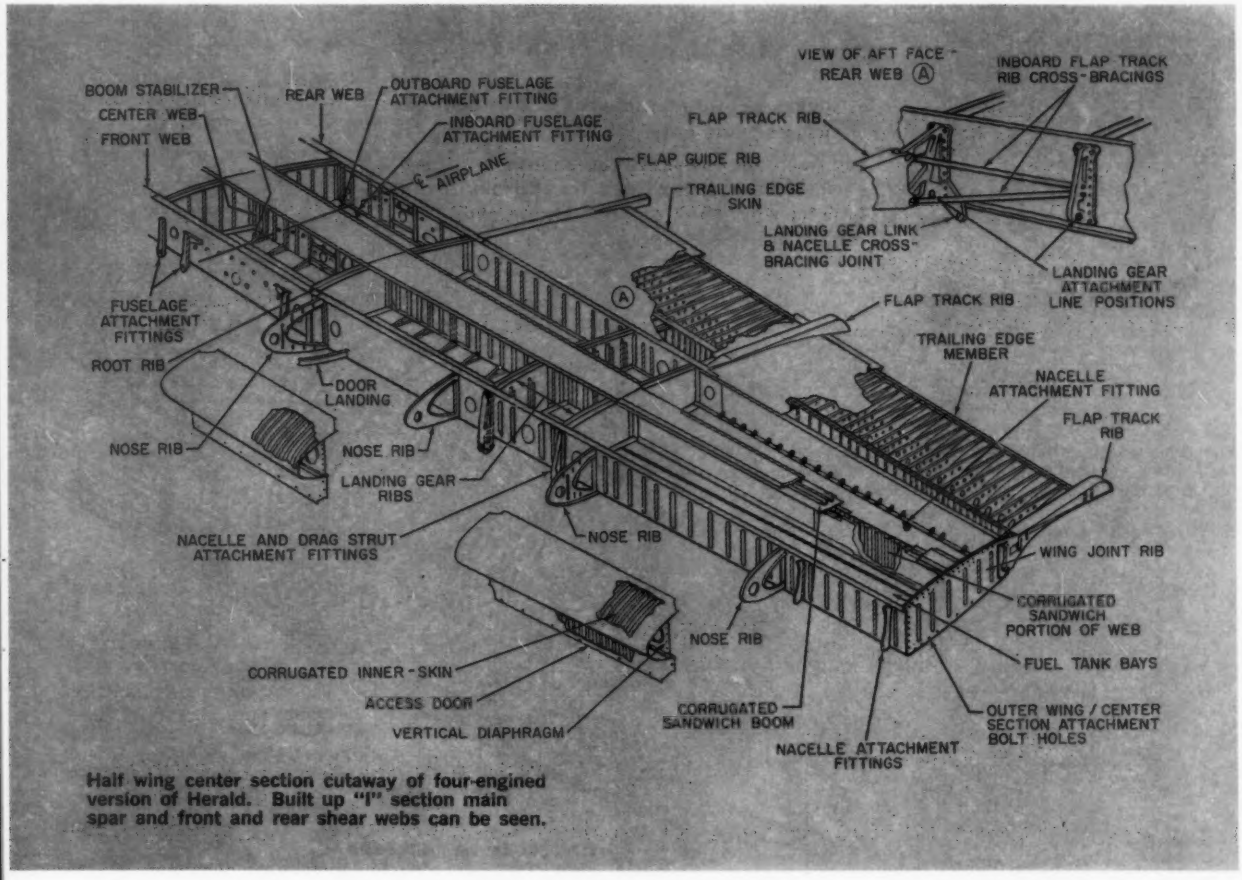


Half wing center section cutaway of four-engined version of Herald. Built up "I" section main spar and front and rear shear webs can be seen.

short-haul versatility . . . continued

Wing Structure

Corrugated-sandwich construction is used to the full extent, and no heavy spars are used in center section. Torsion-box design prevails throughout the wing structure. Heavy bolting flanges, normal to wing surfaces, provide the joints between two outer wing-panels and the center section. Small fairings cover the joints after assembly.

There are three shear-webs in the wing center section. The front and rear shear-webs have conventional stiffeners. The middle shear-web is a sandwich assembly with vertical core corrugations. Light "L"-section spanwise runners at the top and bottom hold capping panels, to form an "I"-section assembly. These top and bottom corrugated-core plates taper in width, and have spanwise corrugations. Torsional rigidity is promoted by small brackets riveted to the shear web. Other panels secured to this basic structure form a two-cell torque box.

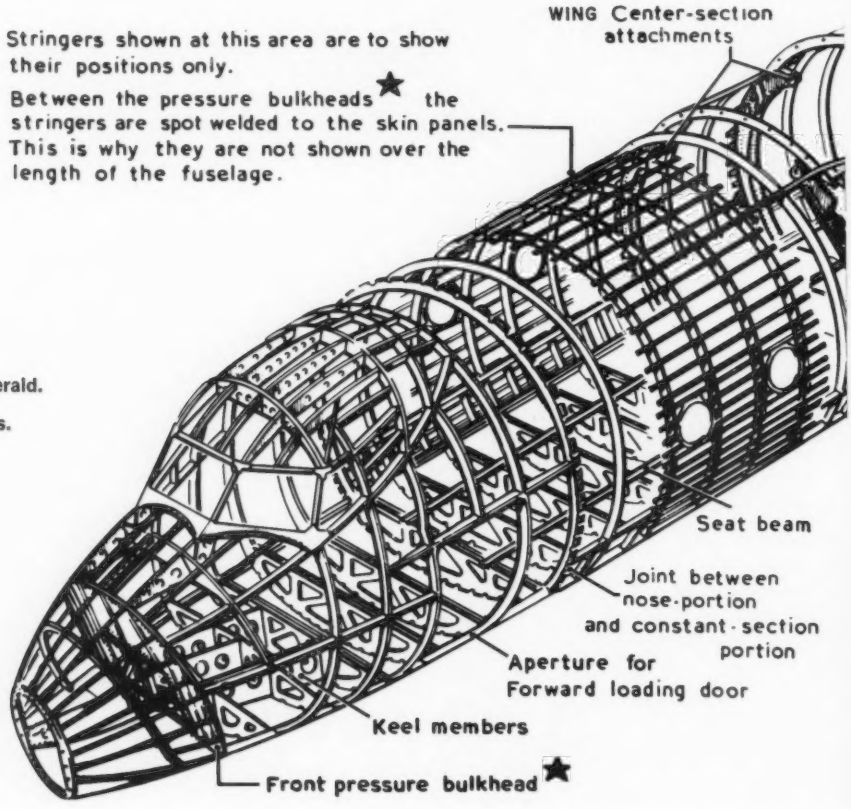
Wing Panels

The outer wing-panels have two shear-webs, which are continuations of the front and rear shear-webs of the center section. There is no physical connection between wing-panel shear-webs and those of center section. Wing loads are transmitted through the bolted flanges which are extensions of end ribs.

Conventional stamped-ribs, notched to take the Z-section stiffeners, are spaced regularly throughout the outer span.

A false spar behind the rear shear-web provides an anchorage for aileron and flap brackets. Heavy guide-rails cantilever out from this spar to carry the Fowler-type flaps operated by hydraulic jacks. Cables are used to actuate flaps and interconnect the two for synchronization.

Along the whole span the leading edge consists of a "D" structure made of a smooth

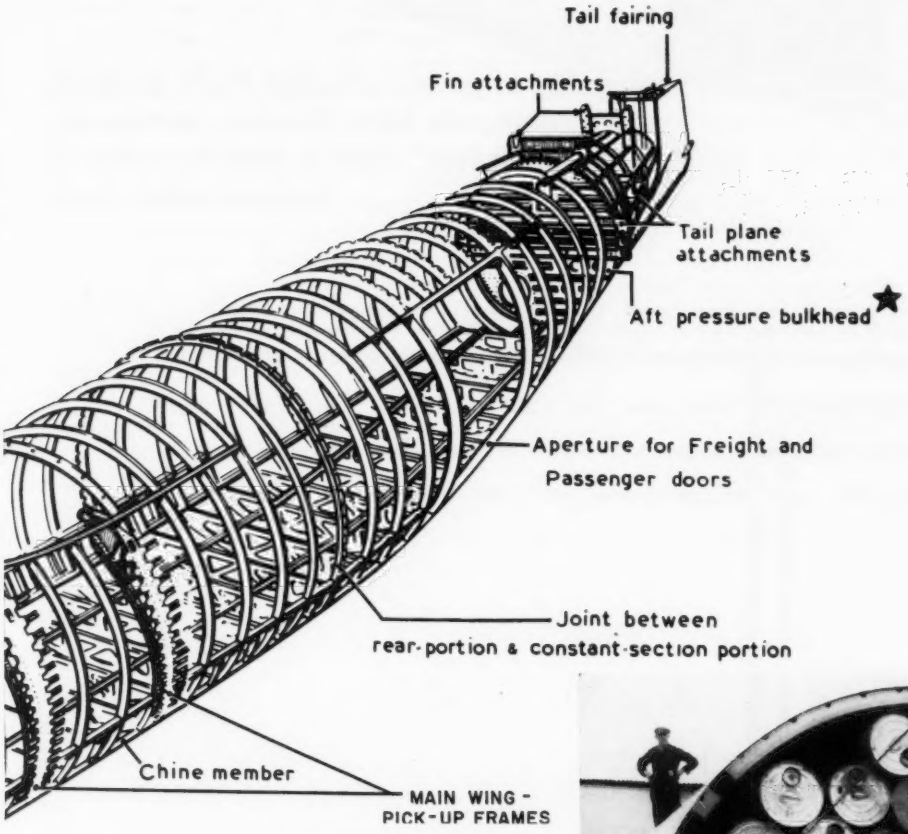

WING Center-section attachments
Stringers shown at this area are to show their positions only.
Between the pressure bulkheads ★ the stringers are spot welded to the skin panels. This is why they are not shown over the length of the fuselage.
Seat beam
Joint between nose-portion and constant-section portion
Aperture for Forward loading door
Keel members
Front pressure bulkhead ★

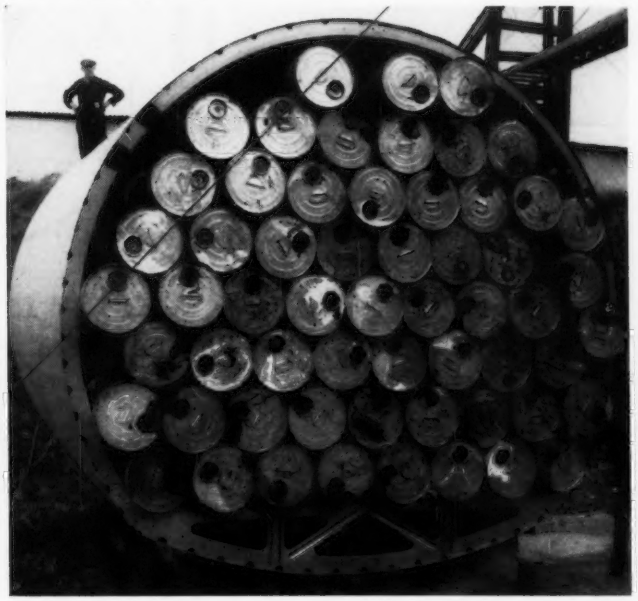
Fuselage structure of four-engined Herald. Turbo-prop version is slightly longer ahead of the main wing pick-up frames.

skin over a corrugated backing-plate. Secondary shear-webs give this structure spanwise stiffness and provide anchorage for housed equipment. A small hinged-panel on the lower surface allows access to equipment along the entire span. Either thermal or electric de-icing can be fitted. Where the thermal type is used the shallow ducts formed in the leading edge, between the corrugated and smooth sheets, are used for air circulation. All the tail surfaces have this type of leading-edge construction along with several spanwise spars and beaded metal skins.

Powerplants

Buyers have a choice of either four Alvis Leonides Major air-cooled radials of 870 bhp each, or two Rolls-Royce Dart turbo-props of 2100 bhp each for take off. In either case, engines are fitted via space frameworks to a fireproof bulkhead ahead of the wing, on a semi-monocoque structure. Engine installation ahead of the firewall is identical to that on the Vickers Viscount. A side intake, inboard of each engine nacelle collects air for engine-bay cooling, accessory cooling, and cabin pressurization. ✦





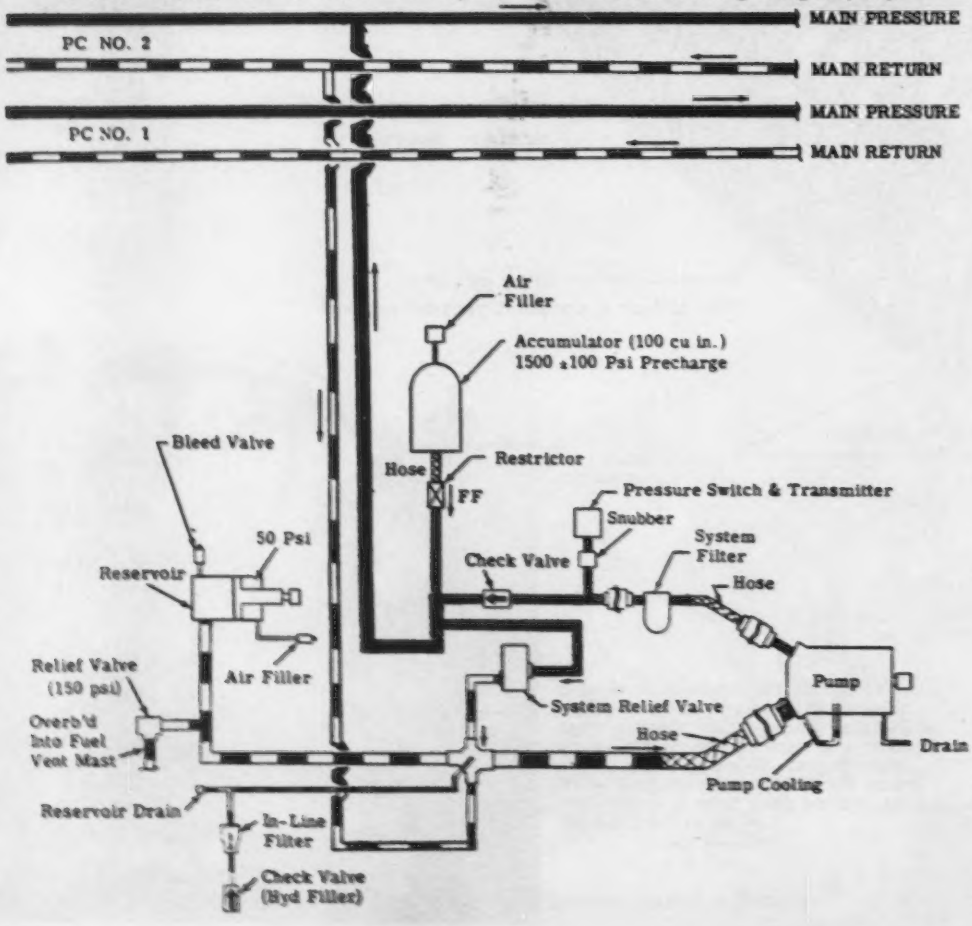
To reduce the explosive force of a pressurized fuselage, should it break while being ground-tested, Handley Page packed test sections with sealed empty paint-drums. Should a minor failure occur, the decompression forces would be reduced since there is a minimum of air in the fuselage.

hydraulics—
contamination control

by J. H. Boucher, controls and hydraulics design, Chance Vought Aircraft

reliability of power-actuated flight controls demands high filtration standards; "filter-patch test" used in field determines contamination level

Power control No. 2 pump-circuit incorporates "In" line filter to stop initial introduction of contamination; filter on outlet side of pump traps contamination originating at pump.



The hydraulic system of Chance Vought's F8U Crusader fighter requires a reliability far surpassing that of earlier systems. This reliability is achieved by rigid filtration standards. Contamination of the hydraulic system can cause failure of the control system, and may result in a loss of aircraft.

An important aspect affecting filtration was the design of manual power-control servo valves. The aerodynamic and servo mechanism requirements for precise control-surface thresholds and positioning accuracies, resulted in the design of close-tolerance manual and electro-hydraulic servo valves. Manual servo valves are used in the main power-control system, and electro-hydraulic servo valves are utilized in the flight stabilization power-control system. The slider stages of these valves have diametrical clearances of 0.0002 in. maximum, and underlaps 0 to 0.0005 in. The signal stages of the electro-hydraulic valves, incorporating miniature motors immersed in oil, have 0.015-in. diam orifices with 0.002-in. flapper clearance. These configurations indicated the need for filtration of two to three microns in both power-control and utility systems. However, this filtration size appeared impractical from both design and maintenance aspects, therefore, the basic design requirement was set at five microns for the main filters throughout.

The optimum location for these filters became a vital consideration. On the tailless Cutlass, with hydraulic power-control only on ailavators, filters were located in wings immediately ahead of servo valves. This required four units with attendant weight penalty and servicing problems. On later airplanes a Navy change directed relocation inboard to the wingfold area, about 10 ft away from the valves for ease of maintenance.

On the Crusader, which had 10 to 12 servo valves, only one main filter per system was located immediately downstream of hydraulic pumps.

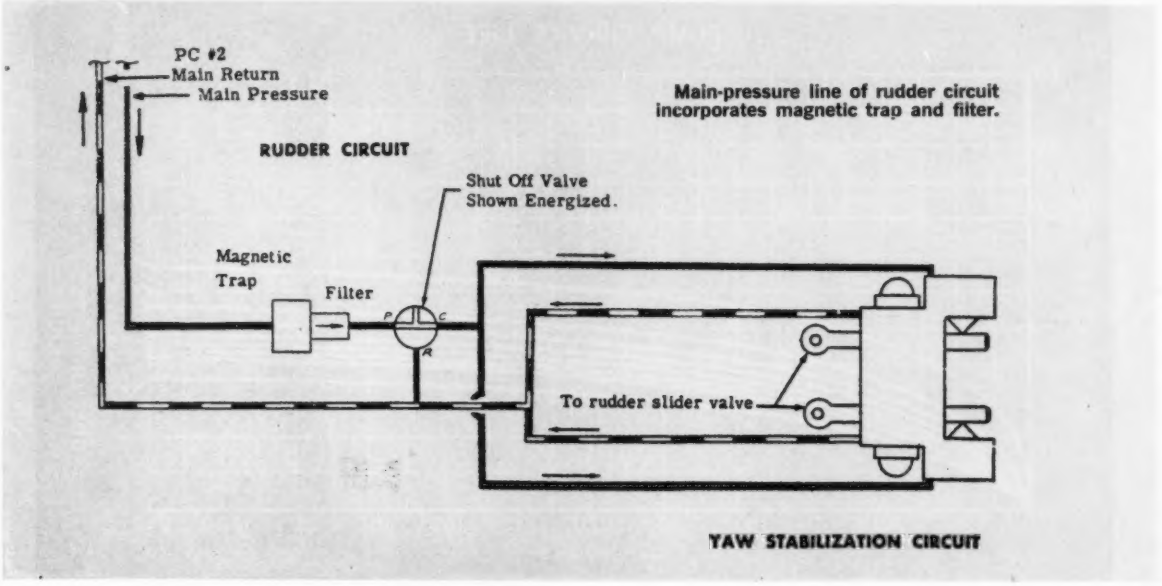
Since one likely way of introducing external contamination is through the fluid medium, primarily in handling. Filters were designed into the system filler-line, to insure automatic prefiltering of fluid during introduction into the system. Consequently, 10-micron in-line paper filters were used.

Electro-hydraulic servo valves incorporating (at the time) the fluid immersed motor "wet coil" pilot stage indicated also the need for magnetic filtration. Lab tests showed that fine ferrous particles, within the filter capacity, were drawn into the magnetic field of the motor and settled on the rotor or valve flapper, creating erroneous pressures at the orifices, hence faulty operation. Magnetic traps and 10-micron sintered metal filters (later combined) were used successfully.

To minimize hydraulic fluid breakdown through exposure to air and high temperatures, an airless or accumulator-type reservoir was used in the Crusader.

Contamination "Filter Patch" Tests

Prompted by a number of silted power-control valve incidents, during an early service period on the Cutlass, a "filter patch" test was developed as an effective inspection method. During these tests, various types of controlled contaminants were introduced upstream of the filters until servo-valve sticking or silting occurred. Four-ounce filter-bowl fluid samples were taken upstream and downstream of the filter, then filtered through No. 40 Whatman filter paper to



Main-pressure line of rudder circuit incorporates magnetic trap and filter.

obtain contamination "patch" samples. Good correlation was found between patch qualities and acceptability criteria. Preliminary standards of patch color, quality and size were established and a test kit was prepared for trial tests on operational Cutlasses.

The filter kit consists of a small electrically-driven vacuum pump connected to a filter flask with a Gooch crucible on top. Several polyethylene sample bottles, a washing bottle, and a supply of Whatman No. 40 filter paper disks are also provided. The filter disk is placed in the crucible, with the vacuum used to hold it on the seal and to expedite the filtration process. An instruction board including reference filter patches is used for the final check of acceptability.

Ground Filter Bank Assembly

The filter-patch test procedure was reinitiated in early Crusader operations, due to increased vulnerability to contamination. A special ground-support equipment filter-bank assembly was put into service. This unit consists of a parallel bank of two sintered-bronze filters, five micron and two micron, in series. By making it mandatory to have this unit connected into the airplane pressure-disconnects anytime a test stand was used, contamination rejections were reduced sharply. This assembly is now being made available for service usage.

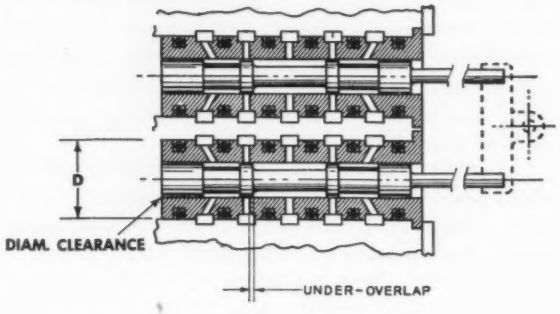
The filter-patch procedure has been incorporated in Crusader maintenance handbooks and been in effect for some time. The inspection period has been increased to 60 hr, in keeping with Navy intermediate inspection requirements.

During another phase of contamination-control studies it was revealed that hydraulic pumps could generate fine metallic particle contamination. Investigation of premature pump failures indicated the need for extending the length and revising the cycle spectrum of initial break-in runs. Here also, filter-patch tests were incorporated, on the outlet filter bowl, and used as a measure of pump quality and continued operational reliability.

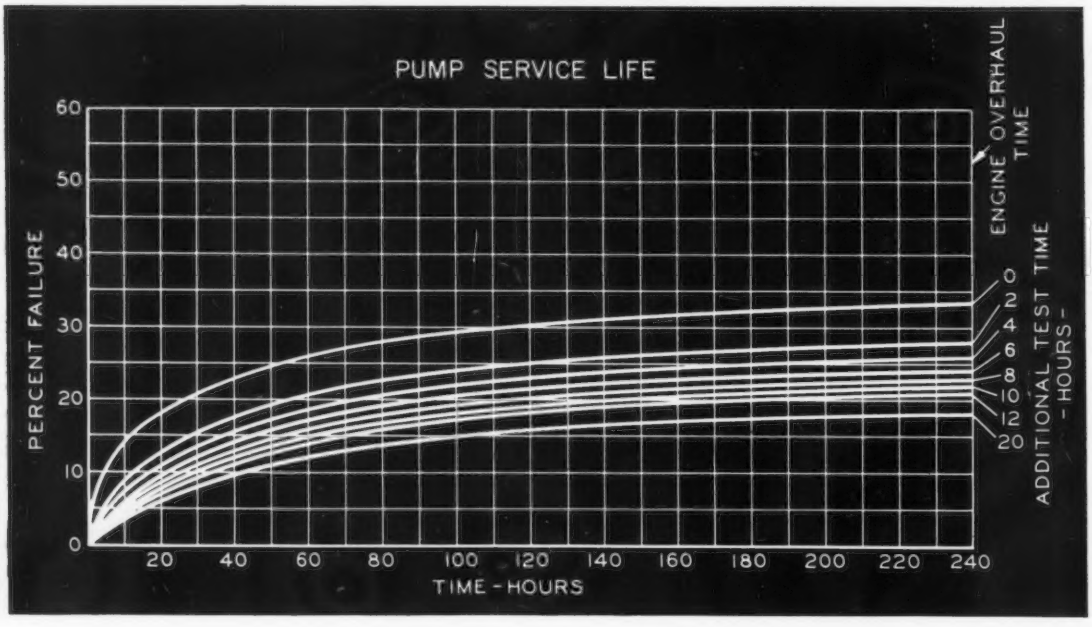
The criteria obtained from these tests were used in establishing design specification objectives, acceptance standards, and procurement specifications.

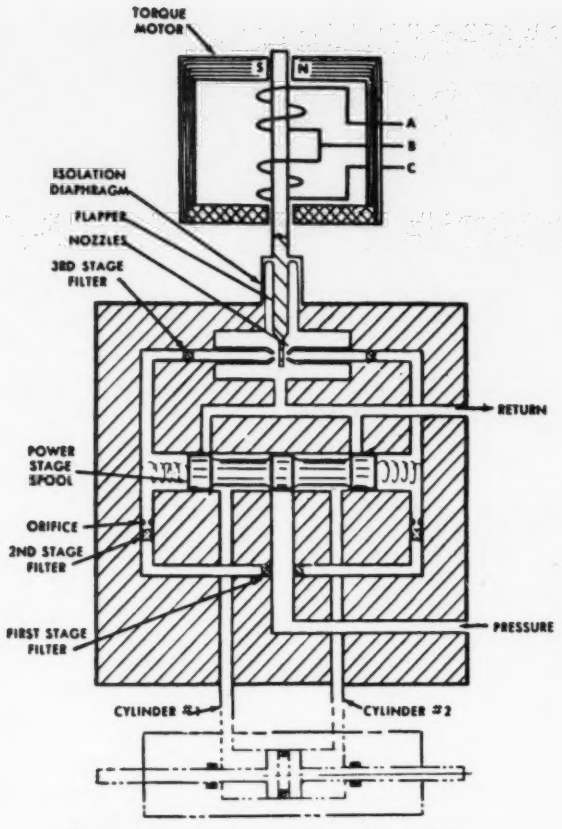
◆

Manual, dual side-by-side servo valve used in main hydraulic system.



Plot of per cent premature pump-failure rate versus total pump-time as a function of run-in time.





Electro-hydraulic servo valve used in flight stabilization power-control system.

Relative size of particles (magnification: 250 times).

Linear Equivalents

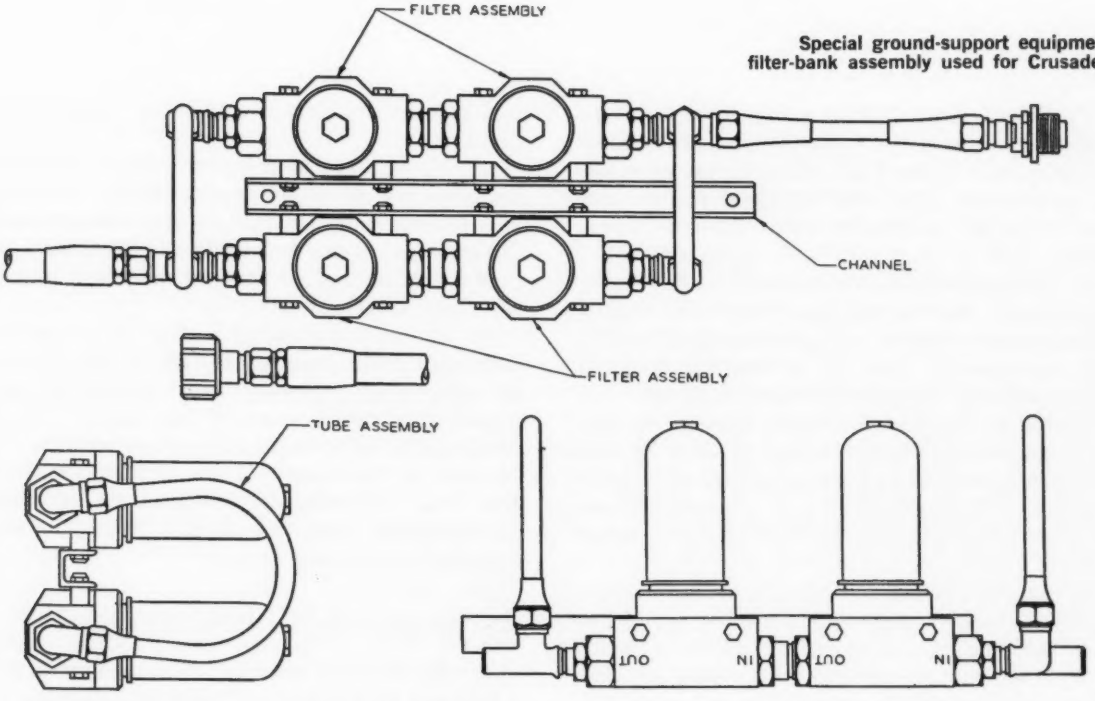
1 Inch	25.4 Millimeters	25.400 Microns
1 Millimeter	0.0394 Inches	1000 Microns
1 Micron	$\frac{1}{25.400}$ of an Inch	0.001 Millimeters
1 Micron	3.94×10^{-5}	0.000039 Inches

Relative Sizes

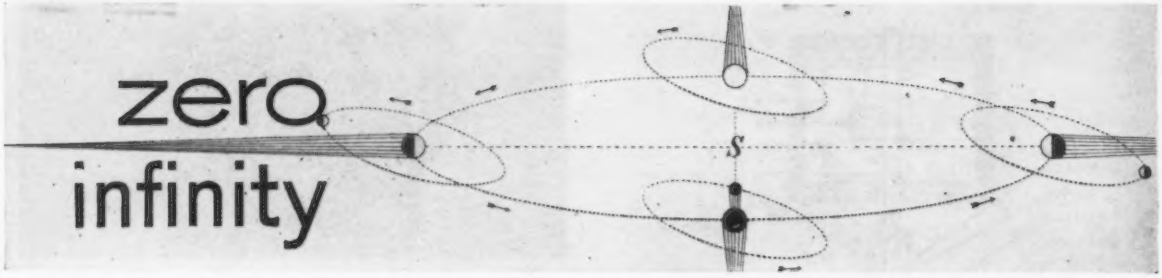
Lower Limit of Visibility (Naked Eye)	40 Microns
White Blood Cells	25 Microns
Red Blood Cells	8 Microns
Bacteria (Cocci)	2 Microns

Screen Sizes

Meshes per Linear Inch	U. S. Sieve No.	Opening in Inches	Opening in Microns
52.36	50	0.0117	297
72.45	70	0.0083	210
101.01	100	0.0059	149
142.86	140	0.0041	105
200.00	200	0.0029	74
270.26	270	0.0021	63
323.00	325	0.0017	44



Special ground-support equipment filter-bank assembly used for Crusader.



This department is created to encourage thinking in new dimensions: thinking that is free of the often constraining influence of immediate difficulties. Technological progress is to a great extent based on departures from the conventional or the status quo. That which is considered illogical or impossible to accomplish, has and always will be so only within the limited compass of accumulated knowledge up to a particular date. Speculative thinking is man's most precious asset. It is hoped that this department will provide an outlet for such thinking and will serve to stimulate further ideas. The implications of the symbolism for this department head are that: while the immediate worth of a concept may range from nil to infinity, its true value will only be determined in the ultimate.

nuclear rocket propulsion

does it hold the answer to long-range space exploration?

by T. F. Nagey
nuclear division, The Martin Co.

The incorporation of nuclear reactors into rocketry will bring forth the Wright Brothers of the space age. Space flight places great demands on high-energy fuels and chemical rockets can meet only the minimum needs of true space flights.

In the propulsion systems to be discussed, the primary heat source considered is a reactor utilizing fission, capable of operating at extremely high temperature. Just as in chemical systems, high operating temperatures are necessary for high specific impulse. Assuming the reactor material temperature to be limited to 5000°F, specific impulses of about 1000 sec are possible with the best propellants. This is a considerable improvement over the best attainable with chemical systems.

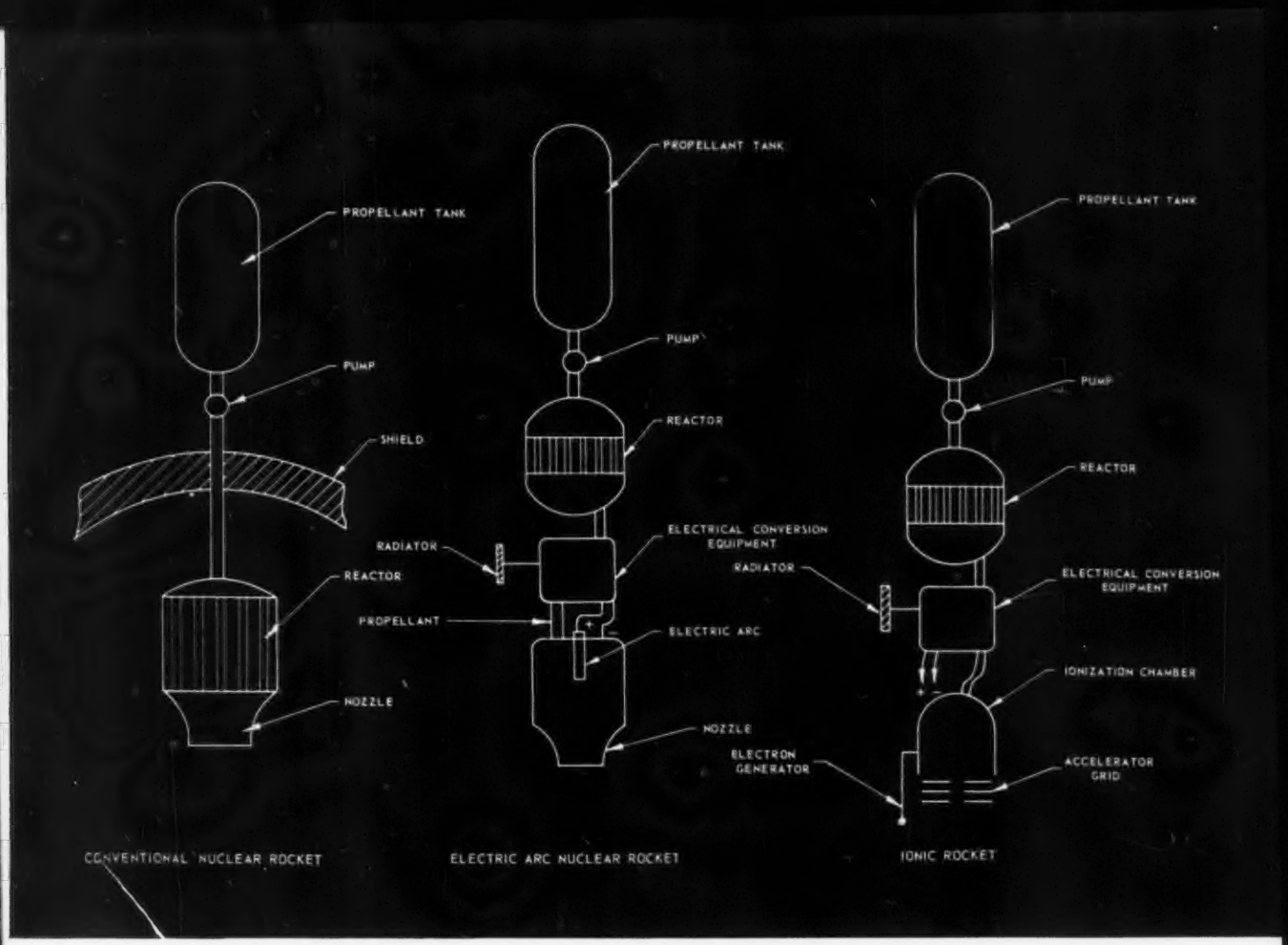
Presently, reactor designers have some real limits to deal with; as an example, one of the fuels, uranium dioxide, melts at 4900°F. In spite of these and other material limitations, nuclear-reactor systems for space vehicles still offer reasonable performances at equivalent chemical temperatures.

To increase reactor performance, materials limitations must be by-passed. Study of the fission process indicates that at high temperatures, the gaseous reactor core and the heated working-fluid would be ionized to allow magnetic fields to serve as container walls.

Use of a reactor as a heat source, for any thermodynamic cycle, poses the serious problem of waste-heat rejection. With thermodynamic cycles, about 80 per cent of heat produced must be discarded as unusable. In space vehicles, heat can only be discarded to space by radiation. Radiator sizes and weights become a major design consideration. Also, the radiator would be very sensitive to meteoric damage.

"Conventional" Nuclear Rocket Propulsion

In chemical rockets, solid or liquid, both a fuel and an oxidizer are needed; however, in a



conventional nuclear rocket, the oxidizer can be replaced by the nuclear reactor. Here, fuel used as reactor coolant becomes heated in passing through the reactor, and is expelled through the nozzle at high velocity.

The specific impulse of any rocket engine varies as the square root of the ratio of the combustion-chamber temperature to the propellant molecular weight. In a chemical rocket, the propellant (oxidizer and fuel) molecular weights are about 10, while in a mono-propellant reactor, the molecular weight can be as low as two (hydrogen). Hence, at equivalent propellant temperatures, the net increase in specific impulse of a nuclear rocket is approximately 2¼.

This factor makes possible specific impulses of about 1000 sec, and a mass ratio (weight, initial/weight, final) of approximately 10. The importance of improvement in mass ratio is best understood when compared to the 1000 required with chemical rockets for the simplest of interplanetary trips.

The practicality of a hydrogen-cooled reactor system for extended planetary travel seems limited due to the difficulty in storing and transporting the hydrogen for extended periods.

The energy required from a typical rocket-propulsion reactor would have to be about 4000 to 5000 megawatts (227 to 284 million BTU per minute). This power requirement is rather high when compared to reactors currently under consideration.

Power level and the temperature required by the system are important considerations. For example, even for a relatively small, well-designed rocket, the temperature rise required of the hydrogen fuel would be about 2300 to 3200°F. Even when using high-temperature materials such as uranium carbide (melting point 4036°F), the construction of a reactor would be extremely difficult. The engineering limitation might be eased if a consumable reactor proves feasible, and the powered flight is limited to a few hundred seconds.

continued on next page

nuclear rocket propulsion . . . continued

Travel from the earth's surface to an earth-orbit station can be accomplished by either chemical or nuclear rockets. High thrusts are needed for orbiting, but not required for flights from orbit to other planets. For these applications, low thrust is acceptable provided high specific impulses exist. This can be achieved by electrical propulsion systems.

Electric Propulsion

Both chemical and "conventional" nuclear rockets are limited as to specific impulse due to materials limitations. Since interplanetary missions are not entirely satisfactory with either or both chemical and nuclear rockets, improved performance is required. Electrical propulsion systems can achieve almost any specific impulse; specific impulses greater than 100,000 seconds are theoretically possible.

An electric propulsion system requires a reactor, a thermodynamic system to produce electric power, and an ionization chamber with an accelerating field. In an ionic system, the electric power is used to ionize the propellant, and to accelerate the ions by a field in the thrust unit.

The ion is an atom or molecule that has a net charge due to the loss or acquisition of an electron. In capturing an electron, the ion becomes neutral, and releases 100 times more energy than obtainable by the most energetic chemical reactions. Even this capture of energy is small when compared to energies obtainable by accelerating ions through electrical fields. Theoretically, resulting velocities approach those of the speed of light.

Since the ionic rocket is capable of low thrusts, to be useful in a propulsion scheme it must first be placed in orbit. Because of its low thrust, the ionic drive must operate throughout the journey, but will not suffice for planetary landings without chemical assist.

The energy of the ion jet is proportional to the square of the ion velocity, but the electrical power plant weight increases also by about the same rate. The thrust increases directly as the first power of the ion exhaust-velocity. Hence, the ion velocity cannot be too high when utilizing normally-accepted electrical power plants. Specific impulses of about 20,000 sec are possible with large but reasonable weights. Larger specific impulses will be possible when thermo-electrical conversion devices are developed. A recently-announced device called a thermo-electron engine utilizes a temperature gradient between two plates with a consequent flow of electricity. The engine has a demonstrated efficiency of about 12 per cent. Highly developed steam electrical power plants, yield slightly over 25 per cent. The promise of this approach is further bolstered by a forecast that an efficiency of 30 per cent can eventually be achieved. Apparently a power plant using this principle could be built to yield as much as 15 kw per cubic foot of volume. A conventional plant of the best design can have a capacity of only 0.3 kw per cubic foot.

Of the various methods of obtaining ions, high-temperatures and chemical reactions are not the practical ways. Vaporized alkali metals need only be brought in contact with hot tungsten or platinum surfaces to produce ions with an efficiency approaching 100 per cent. The ions thus produced can then be accelerated by an electrical field.

If only positively charged ions are accelerated, a space charge will result on the ship, and stop further ion ejection. This can be corrected by injecting electrons, into the system, to neutralize the jet. Neutralization allows for much higher plasma densities and smaller exhaust areas. The consequent neutralized fluid is called a plasma. For neutralized systems, plasma accelerators are required and not electrical fields. The plasma accelerator would be a magnetic field; electrical fields would accelerate oppositely charged particles in opposite directions.

Plasma rocketry, to be feasible, would require research in the field of high-current ion sources. High-current ion jets are still very inefficient; in order to produce an ampere of ions, about 50 kw of electrical power are required. In spite of this, if the resulting plasma is accelerated to a high velocity, the inefficiency of ionization can be made insignificant compared to the ultimate power possible in the beam.

Many parts of this system are technically problematical and the extreme reliability requirements of interplanetary travel create even more serious problems. Travel time to Mars with a plasma propulsion system, is approximately two years. This is only slightly longer than needed by a chemically-propelled ship with a poorer mass-ratio. ✦

AIRCRAFT & MISSILES MANUFACTURING DIGEST OF RECENTLY PUBLISHED TECHNICAL MATERIAL

producibility REVIEW

DESIGN

SAUNDERS-ROE P. 531. *Flight*, (August 8, 1958). 5 pp. Development, design and performance details of a new general-purpose helicopter with a free-turbine engine. Cutaway revealing design details included.

THERMAL STRESSES IN DESIGN, (Part 3). S. S. Manson. *Mach. Des.*, (August 7, 1958). 8 pp. Basic concepts of fatigue in ductile materials.

THERMAL STRESSES IN DESIGN, (Part 4). S. S. Manson. *Mach. Des.*, (August 21, 1958). 4 pp. Causes of fatigue in ductile materials.

HALFWAY TO INFINITY . . . A PRIMER ON EARTH SATELLITES. J. R. Hurley and J. J. Taborek. *Mach. Des.*, (August 7, 1958). 4 pp. Summary of basic relationships for satellite launching and orbital motion.

OUR COMPLEX WEAPON SYSTEM. *Missile Des. & Devel.*, (August 1958). 4 pp. An analysis of current design trends.

THE SELF-SUFFICENT VEHICLE. D. M. Desoutter and D. Baker. *Aero.*, (August 1958). 8 pp. Design features and performance details of Fairey Rotodyne discussed.

COMMERCIAL AIRCRAFT OF THE WORLD. *Flight*, (July 25, 1958). Issue devoted to coverage of design features and performance characteristics. Cutaways of structural configuration are included.

BRITAIN'S LARGEST CONVENTIONAL HELICOPTER. *Aeroplane*, (July 11, 1958). 5 pp. Development, design and performance characteristics of Westminster, turbine-powered prototype. Structural cutaway illustration included.

HYDROMAGNETIC SHOCKS USED IN NUCLEAR FUSION ENGINE. C. F. Johnson. *Av. Age*, (August 1958). 4 pp. An outline of design concept and discussion of some engineering parameters.

THE CASE FOR PNEUMATICS. J. Wotton. *Acft. Eng.*, (July 1958). 9 pp. Detailed review of possibilities and limitations of high and low-pressure systems used in aircraft.

MATERIALS and PROCESSES

CURE SHRINKAGE OF EPOXY SYSTEMS. H. L. Parry and H. A. Mackay. *SAE Journal*. Discussion of volumetric shrinkage studies with Epon 828.

MOLYBDENUM IS HERE TO STAY. J. L. McCloud. *Met. Prog.*, (August 1958). 4 pp. Protective coatings for high-temperature applications are described.

PH STAINLESS STEELS BEAT THE HEAT. J. N. Barnett and W. W. Rohde. *Aero. Procur.*, (August 1958). 2 pp. Background information on precipitation-hardening steels for buyers.

W-545 . . . A BETTER TURBINE DISK ALLOY. J. T. Brown. *Met. Prog.*, (August 1958). 4 pp. New iron-base alloy with 0.03 per cent boron content combines high-temperature stress-rupture strength and ductility.

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2000 F STRUCTURES ARE POSSIBLE NOW. H. A. Pearl. *SAE Journal*, (August 1958). 2 pp. Advantageous combinations of high-temperature materials, designs, and thermal insulation barriers are discussed.

ZIRCONIA AND ALUMINA COATINGS GIVE SHORT-TIME 3000 F STEEL PROTECTION. J. V. Long. *SAE Journal*, (August 1958). 2 pp. Discussion of techniques used in flame spraying refractory oxides, diffusing aluminum into the surface and baking on cermet coatings.

PRODUCTION

MACHINING HONEYCOMB. *Acft. Prod.*, (August 1958). 2 pp. Mushroom-type cutters and polyethylene-glycol chucking as used by Northrop Aircraft discussed.

DRILLING TECHNIQUE SAVES TIME AND MONEY ON BOMARC RADOME. D. L. Head. *Av. Age*, (August 1958). 2 pp. Boeing-developed method prevents delamination of fiberglass layers, extends tool life, and combines drilling with countersinking.

MEASURING SCRATCHES ACCURATELY . . . REDUCES REJECTS. B. Siebel and F. R. Miller. *Tool Engr.*, (August 1958). 3 pp. Optical method developed by Boeing measures within ± 0.00005 in.

BIAXIAL STRETCH-FORMING. *Acft. Prod.*, (August 1958). 1 p. Brief description of machine used for forming integrally-stiffened missile-skins.

FORMING HIGH-STRENGTH MATERIALS. W. W. Wood. *Tool Engr.*, (August 1958). 7 pp. Elevated-temperature creep-forming method used at Chance Vought Aircraft solves springback, buckling and elongation problems.

BAND-GRINDING. H. J. Pearson. *Acft. Prod.*, (August 1958). 9 pp. Discussion of abrasive-belt grinding with a rise-and-fall copying motion. Process originated by the Aircraft Division of Armstrong-Siddeley Motors, Ltd., for finishing turbine blades.

INTERFEROMETER CHECKS GAGE-BLOCK ACCURACY. *Tool Engr.*, (August 1958). 3 pp. Rapid measurement of the parallelism of gage-block opposite faces is made possible by instrument developed at the National Bureau of Standards.

BOOKS RECEIVED

HOW CAN WE HURDLE THE "MATERIALS ROADBLOCK"? I. Stambler. *Av. Age*, (August 1958). 4 pp. A survey of materials needs for the next 10 years.

THE HELICOPTER. F. Shapiro. *Macmillan*, 1958. 269 pp. $4.50. Aimed to the general reader interested in aviation, this book provides the fundamentals of rotary-wing craft with clarity. The necessary background for understanding helicopters is progressively developed through simple diagrams, illustrations, and jargon-free language. Historical background, present applications, and future possibilities are also discussed.

PRINCIPLES AND APPLICATIONS OF RANDOM NOISE THEORY. J. S. Bendat. *Wiley*, 1958. 431 pp. $11.00. This book is prepared for use by the engineering student, the research scientist, and the practicing engineer, without a previous knowledge of probability theory or of Fourier integrals. First four chapters are devoted to explanation of principles of random noise analysis and optimum filtering techniques. Remaining six chapters discuss some difficult noise problems, their mathematical solutions, as well as methods to draw physical designs and interpretations. Some familiarity with basic circuit theory, servomechanisms, and analog computers is assumed by the author.

INTRODUCTION TO A STUDY OF MECHANICAL VIBRATION. G. W. Van Santen. *Macmillan, second edition*, 1958. 310 pp. $8.50. The scope of this book extends from elementary theory of mechanical vibrations to problems encountered in practice. Chapters are also included on the theory of isolation, sound and other wave phenomena, balancing, damping, principles of equipment for measuring vibration, instruments, as well as practical hints on vibration measurements.

GEAR TOOTH LOADS. E. Buckingham. *Massachusetts Gear & Tool Co.*, 1953. 75 pp. $3.00. Compiled to assist engineers in the design of gear trains, this book presents fundamental analytical methods to determine polar moments of inertia, dynamic loads, limiting wear loads, and limiting beam loads for frequently used types of gears.

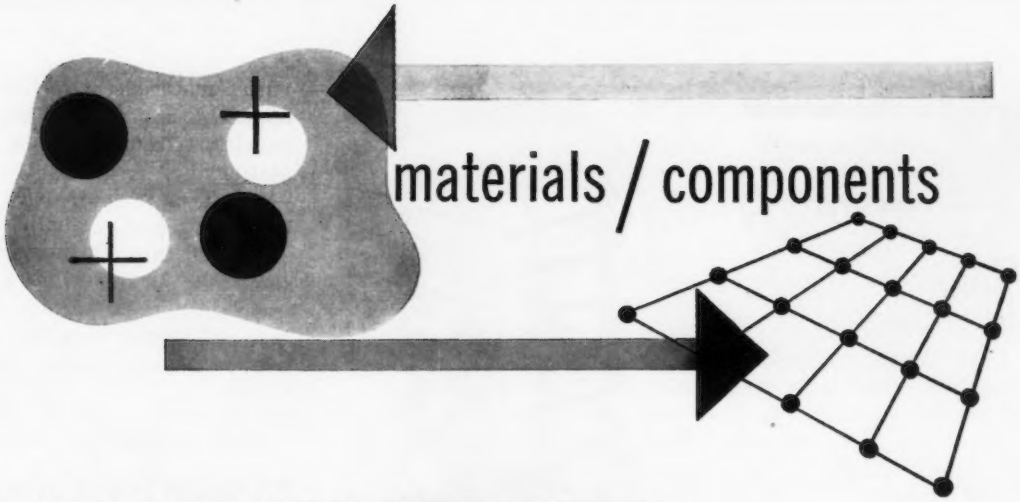
REVIEWED IN THIS ISSUE

Periodicals and Papers

Aero. Aeronautics (British)
Aerop. Aeroplane (British)
Aero Procur. Aeronautical Procurement
Acft. Eng. Aircraft Engineering (British)
Acft. Prod. Aircraft Production (British)
Av. Age Aviation Age
Flight Flight (British)
Mach. Des. Machine Design
Met. Prog. Metal Progress
Missile Des. & Devel. Missile Design & Development
SAE Journal Society of Automotive Engineers Journal
SPE Journal Society of Plastics Engineers Journal
Tool Engr. Tool Engineer

Books Received

The Helicopter Macmillan
Principles and Applications of Random Noise Theory Wiley
Introduction to a Study of Mechanical Vibration Macmillan
Gear Tooth Loads Massachusetts Gear & Tool Co.



ELECTRIC MOTORS USED TO FEATHER PROPELLERS

Analytical refinements and weight-saving approach to electric motor design has resulted in a family of continuous-duty, light-weight electric pump motors, usable for feathering propellers. The Task motors feature special design approaches as well as careful selection of materials. Initial production is a 400 cycle, 200 v, 3-phase design for high horsepower propellers.

Model 424 (shown), replaces an existing unit which is 4.2 lb heavier. The Task unit weighs 7 lb, draws 19 amps, and may be operated continuously. Ambient temperature range is —65° to 165°F.

The unit is lubricated and cooled by oil circulated through the rotor and around the stator by an internal pumping system.

Task Corp.

Circle 158 on postcard for more data

B-52G USES AIRBORNE LOX CONVERTER

A 25-liter liquid oxygen converter, designated the ME-3, is used in the B-52G.

The ME-3 is made of a stainless steel inner shell, aluminum outer shell, and weighs

40 lbs, 30 lbs. lighter than the military specification limit. It can be installed in a space 18⅝ in. high by 19¾ in. diam.

Under normal conditions the ME-3 will supply enough oxygen to sustain four men at altitudes above 35,000 ft. for 30 hr. The 25 liters of liquid oxygen convert to 21,525 liters, or 760 cu ft or gaseous breathing oxygen. At operating pressure of 300 psig, it will deliver more than 150 liters of gaseous oxygen a minute.

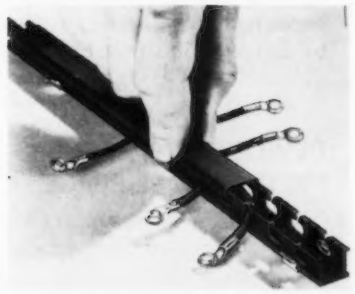
Linde Co.

Circle 157 on postcard for more data

MINIATURE WIRING DUCT MADE OF VINYL PLASTIC

"Miniature" wiring duct provides a good wireway for electronic installations. Complete range of small cross sections features snap-in slot design which allows wire to be laid after terminals have been attached.

For standard mounting,



an ordinary screw may be used through a hole drilled in the base. Duct is easily cut with a fine-tooth saw.

Panduit Corp.

Circle 164 on postcard for more data

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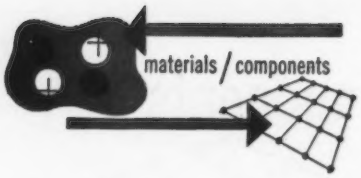
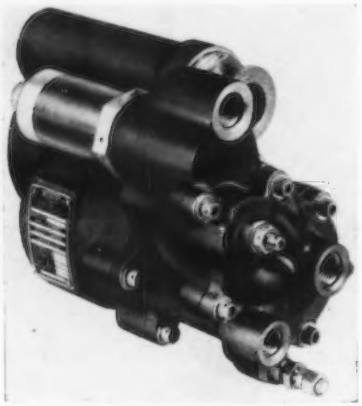


FUEL PUMP FOR JET ENGINES

An hydraulic motor-driven vane type fuel pump package for jet engine starting, eliminates the need for oversize pumps to supply a large volume at low pump speed.



A piston type hydraulic motor drives the vane pump and impeller. Motor speed is controlled by a flow control valve.

The starting fuel pump is designed to shut off automatically when the main pump takes over.

Pump operates on an inlet pressure of 5 psi above fuel vapor pressure and is designed to deliver 4500 pph at 150 psi.

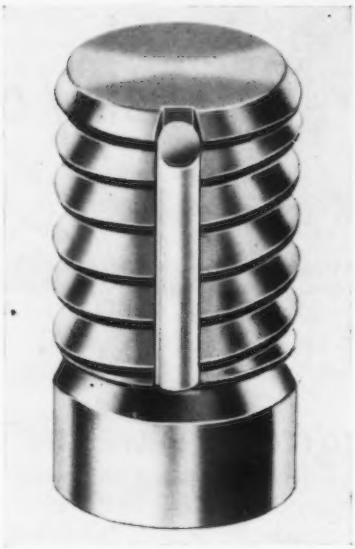
Vickers Inc.

Circle 154 on postcard for more data

DEVICE FOR FASTENERS PRECLUDES SLIPPAGE

Long-Lok inserts are used in fastener applications to lock mating threaded parts, anchor adjusting screws, and to seal threaded holes.

Inserts can be incorporated, generally, in any fastener having male threads. The fastener is manufactured with a root-deep axial slot in the male threads, which is permanently

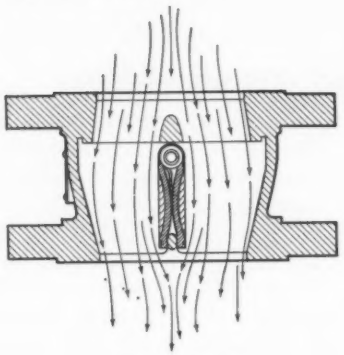


filled with a material engineered for each particular design application.

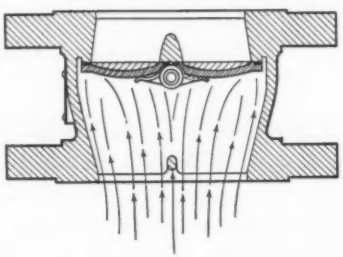
Voi-Shan Mfg. Co.

Circle 156 on postcard for more data

CHECK VALVE HANDLES LIQUIDS, GASES



NORMAL FLOW



REVERSE FLOW

Newly-designed split-flapper check valve is adaptable to handling flow of all types of gases and liquids in missile ground support. Through use of varied materials, it can be made applicable to operational temperatures from cryogenic levels at 1000°F.

Twin flappers, opening in the direction of normal flow, are supported through the center of the piping. In the event of backward flow, their spring mounting, and short, compact profile result in fast closing of the valve.

The Garrett Corp.

Circle 163 on postcard for more data

TITANIUM SHEET STOCK STANDS 100 TON/INCH; USED IN MACH 3 CRAFTS

Titanium sheet to withstand upwards of 100 tons pressure per square inch, the stresses inflicted on manned aircraft flying at 2100 mph, is now on the market.

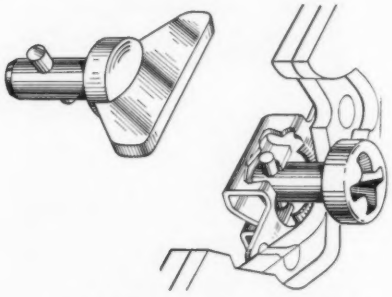
Initial shipments went to researchers seeking to lighten the new Mach 3 fighters and bombers scheduled for 1960 production.

Titanium Metals Corp. of America

Circle 162 on postcard for more data

MINIATURE FASTENER RATED AT 100 LB LOAD

A miniature ¼ turn fastener has been designed with a 10 in. lb locking torque and a 100 lb nominal rated load.



Fastener is available with wing type head, or 5 different types of slotted heads.

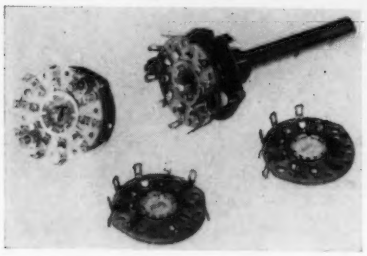
Suited for installation of printed circuit boards or small inspection panels on aircraft and missiles.

Monadnock Mills

Circle 151 on postcard for more data

HALOFLUOROCARBON USED IN MINIATURE SWITCHES

Electrical and mechanical properties of halofluorocarbon plastic make it suitable for use in small rotary switches.



Used for multiple circuit selection, one specific switch, which has a 1 3/32 in. diam, is employed in the miniaturization of military communications, navigation, and detection equipment.

The rotor itself is of colorless, non-flammable "Kel-F" brand halofluorocarbon plastics. It is chemically inert, resists thermal shock, and has high impact strength at low and high temperatures.

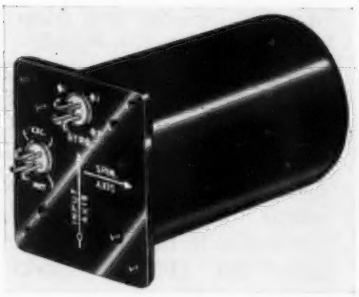
Minnesota Mining & Mfg. Co.

Circle 153 on postcard for more data

LOW FRICTION THRESHOLD UPS RATE GYRO RANGE

Innovations in rate gyro design and manufacturing techniques permit wider performance ranges in control systems of high-speed aircraft.

Through reduction of the threshold friction, high performance characteristics at lower input rates are obtainable.



Ultra-sensitive damped rate gyro operates from a maximum input rate of as low as 3 deg per sec with a natural frequency down to 8.5 cycles per second.

R. C. Allen Aircraft Inst. Div.

Circle 161 on postcard for more data

FLUORIDE REVEALED AS ROCKET FUEL OXIDIZER

Perchloryl fluoride, a rocket fuel oxidizer, is the first oxidizer specifically designed for rocketry. It offers important advantages in storability, stability, and superior performance. The calculated specific impulse with hydrazine is 270 sec at a chamber pressure of 500 psia (frozen equilibrium).

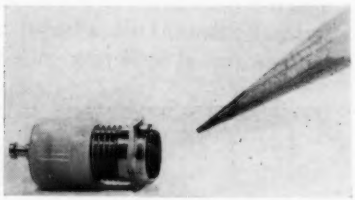
Storable in liquid form without refrigeration, PF does not undergo decomposition and does not corrode common materials of construction such as steel, aluminum, brass, and some plastics.

Pennsalt Chemical Corp.

Circle 159 on postcard for more data

INDICATOR LIGHT GIVES 180 DEG VISIBILITY

A Color-Light that projects 0.125 in. from the panel it is mounted on has been announced. Type 855R, the subminiature incandescent indicating



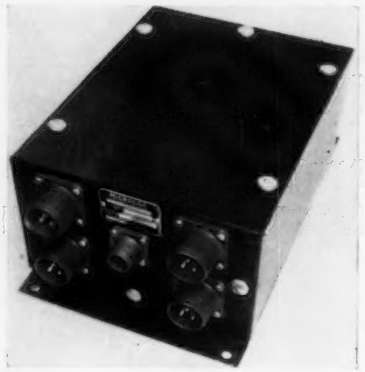
light may be hot stamped with numbers or letters. Lights provide full 180 deg visibility.

The Sloan Co.

Circle 155 on postcard for more data

FIRING DEVICE STORES, CONVERTS, ENERGY

Developed to fulfill the requirement for the destructor system in missiles and unmanned airborne systems, the Microloc 51050 energy storage firing device isolates and shields the explosive from the electrical system.



In operation the device converts a low current 28 v signal input to a high current output to cause simultaneous ignition of a number of electric squibs connected in parallel.

Microloc Corp.

Circle 152 on postcard for more data

PRESSURE SWITCH FEATURES SNAP ACTION

A new pressure switch features an intermediate mechanical snap action that insures trigger switching of the electrical switch element. This prevents welding of contacts that ordinarily result from contact chatter. The switch is designated series 9000.

The unit is qualified and available in pressure settings from 5 to 4000 psi. It is suitable for use with hydraulic fluids or compressed air. Weights vary from 0.25 to 0.40 lbs.

Hydraulic Research & Mfg. Co.

Circle 160 on postcard for more data

METAL-FORMING MACHINE PACKS 1580 TON PUNCH

A new metal working machine develops more than 1580 tons of force and stretches a steel ring weighing over 1½ tons with about the same ease that a housewife forms pie dough.

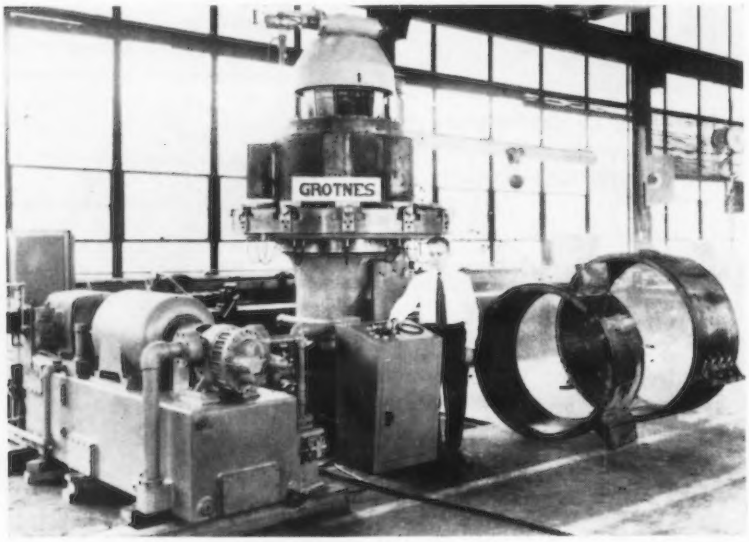
Entire operation is performed without heating. Power is so great that the metal flows cold to the desired size and diameter.

Less time is consumed in the coiling operation. The part can be as much as 1 in out-of-round when leaving the coiling roll. The Grotnes expander performs both the sizing and rounding operations simultaneously.

Illustration shows 3000 lb part in place on expander; hydraulic pump and electric motor at left, and right, two rings expanded and sized on the machine.

Machine can expand 60 square in. of metal having a yield strength of 46,000 psi.

It is fitted with replaceable dies machined to the desired finished internal diameter of the parts which it is to process.



Electric drill device at the top rotates the drawbar nut which moves the cone up and down on the drawbar for the purpose of adjusting the expanded jaw diameter.

Grotnes Machine Works, Inc.

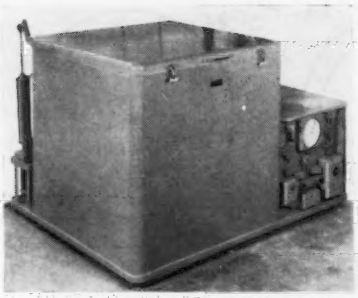
Circle 169 on postcard for more data

LOW TEMP UNIT "AGES" NEW STAINLESS STEELS

Industrial low temperature unit can bring 350 lb of AM-350 stainless steel per hour from plus 80°F to minus 120°F. Lid of the 64 cu ft chamber is opened and closed by an air lift device mounted on the rear of the chamber.

Designated the 4SR-120-64, unit is designed for "quick aging" of the newest stainless steels now used in the aircraft and missiles field. Stability is achieved at a transformation temperature below that of room temperature.

Chamber measures 48 in. by 48 in. by 48 in. It has a net thermal capacity of approximately 8500 btu per hour at minus 120°F. Mechanical air convection in the chamber facilitates the chilling operation. Chilling chamber is electric welded liquid-tight and galvanized.



Unit is efficient for precipitation hardening of stainless steels and any type of production chilling. The built-in system of temperature adjustment, and quick pull-down from ambient to minus 120°F, offer the speed and range to handle the newer types of steel with maximum efficiency.

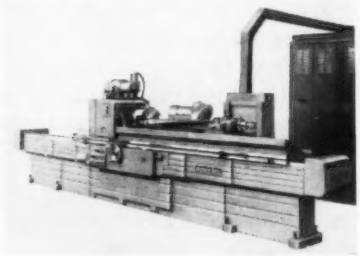
Cincinnati Sub-Zero Products

Circle 168 on postcard for more data

MILLING AND GRINDING BY NUMERICAL CONTROL

Profiling machines have been designed for numerically controlled three dimensional machining around axis of work.

Operated from any high performance numerical control system, the machines produce such parts as cams, templets and airfoil contours of steam turbine buckets and jet engine blades.



Profilers, equipped for milling and grinding operations, incorporate grinding, dressing and dressing compensation functions.

Work table casting, weighing over a ton, moves on V and flat ways. A pull of only 14 lb keeps it moving. Gross slide, of aluminum casting, supports interchangeable milling and grinding assemblies.

Ex-Cell-O Corp.

Circle 171 on postcard for more data

SEMI-CONDUCTOR PARTS MADE IN BAKING OVEN

Semi-conductor components can be outgassed and brazed or fused under closely controlled vacuum conditions in a newly developed "baking oven."

Unit is complete with its own vacuum pumping system, special electrical heating equipment, and temperature regulating and indicating instrumentation. It has a double-walled chamber, with the space between the inner and outer shell packed with glass fibre insulation. The front flange of the chamber is designed for attachment to the inert-gas-filled "dry box" in which the semi-conductor components and subassemblies are customarily manufactured.

Components are placed on horizontal racks within the vacuum chamber, which is then evacuated to a pressure of 10^{-6} mm. and heated to approximately 450 deg C for the proper length of time.

F. J. Stokes Corp.

Circle 165 on postcard for more data

ORTHICON TUBE WITHSTANDS VIBRATION

A new rugged image orthicon tube (WL-7198), for applications subject to extreme environmental conditions of shock, vibration, temperature and humidity is now available.

The WL-7198 operates

throughout the range of vibration specified in MIL-E-5272A, paragraph 4.7, procedure I, which demands 10 G's acceleration up to 500 cps. At 5 G's acceleration (50 to 500 cps), the tube shows horizontal resolution of at least 350 lines. Thirty G's shock does not impair subsequent tube performance.

In addition to ruggedness, the WL-7198 is a very sensitive tube. At least 250 lines horizontal resolution may be obtained with only .0003 foot candles illumination on the photocathode of the tube.

Electronic Tube Div.
Westinghouse Electric Corp.

Circle 173 on postcard for more data

SPEED INDICATION IS NOW "PACKAGED"

Speed of industrial processes or machines is accurately indicated by an inexpensive speed indicating system.

System combines d-c tachometer generator with a 4½

continued on next page

in. panel-mounted meter. Range is from 100 to 12,000 rpm.

A low voltage cable connects the generator and indicator and can be as long as 500 ft without affecting accuracy. A permanent - magnet generator eliminates need for batteries, external power, or periodic calibration.

Servo-Tek Products Co.
Circle 167 on postcard for more data

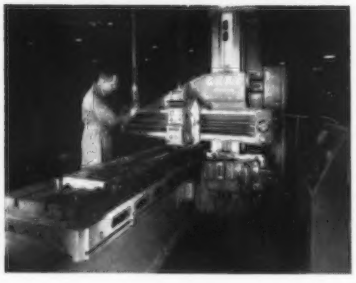
DIAMOND CUTTING WHEELS

Manufactured by a new process, diamond cut-off wheels, called "Diatronic," permits cutting of fully-hardened steels, silicon and germanium crystal, glass tubing, tungsten carbide, etc., with great accuracy.

Diatronic wheels, .006 in. x 3 in., have rim tolerances of plus .0005 in., minus 0.

Navan Products, Inc.
Circle 166 on postcard for more data

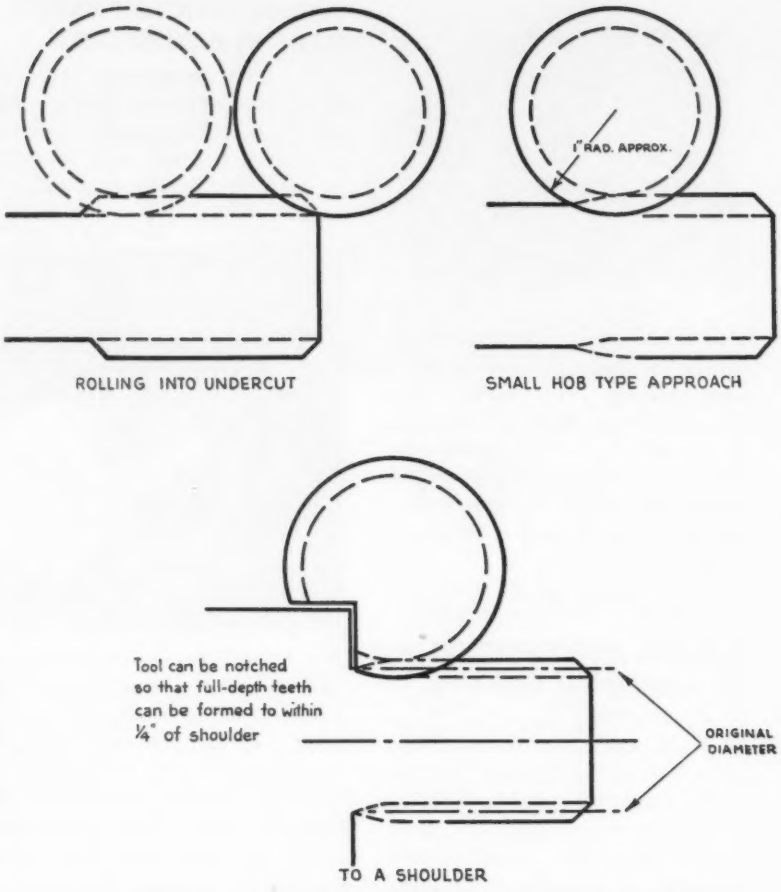
PLANER ADJUSTED FOR DOUBLE-TRIPLE CUTTING



Square lock design on this planer allows effortless heavy duty work. There is no idle return stroke, since it cuts both ways. A lever and button are activated to convert to double cutting.

Rough and semi-finish planing are accomplished at the same time with the machine offered in both double housing and openside design.

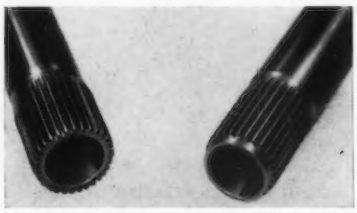
G. A. Gray Co.
Circle 170 on postcard for more data


ROLLING INTO UNDERCUT
1" RAD. APPROX.
SMALL HOB TYPE APPROACH
Tool can be notched so that full-depth teeth can be formed to within ¼" of shoulder
ORIGINAL DIAMETER
TO A SHOULDER

SPLINE-ROLLING EXTENDED TO TUBULAR PARTS

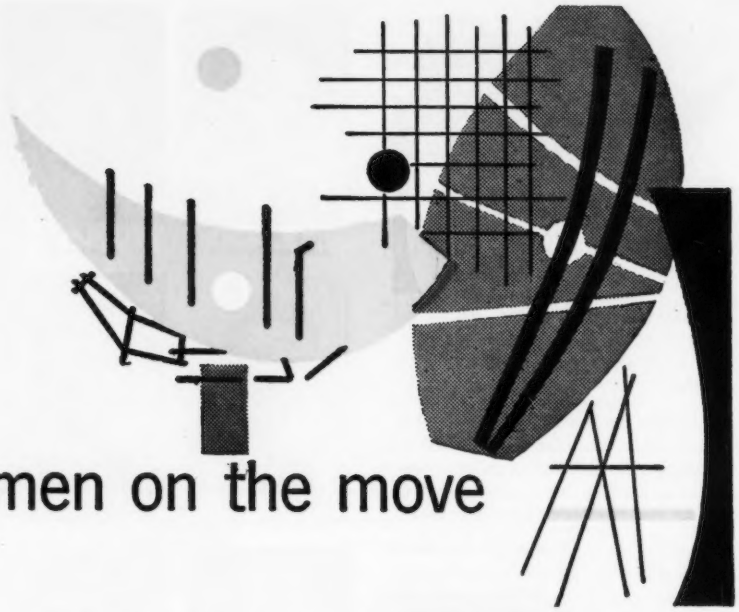
The fast "Roto-Flo" spline-rolling process has been extended to permit the rolling of splines and serrations on even thin-walled tubular parts. Tooling for Roto-Flo cold-rolling machines permits quick production of splines or serrations on tubing ranging from ½ in. to about two in. OD. Reciprocation of the new cylindrical forming racks is combined with an axial feed of the blank to cold roll splines of any reasonable length.

Any desired length splines can be formed on solid-shaft parts as well as tubular parts. Splines and serrations up to 12 in. long are now being cold rolled. Thin - walled tubular parts having as little as 0.075 in. from the root of the tooth to the ID of the tube can be splined



or serrated on Roto-Flo machines.

Michigan Tool Co.
Circle 172 on postcard for more data



men on the move

ALLEN M. CREIGHTON will manage the new Combat Surveillance Group of the Military Electronics Div., Motorola, Inc.

E. J. GROTH will be group scientist and assistant manager.

DR. WILLIAM J. PIETENPOL was appointed vice president and general manager of the Semiconductor Div., Sylvania Electric Products Inc.

WALTER SERNIUK was appointed manager of the Amherst Engineering Laboratory of the Electronic Systems Div. of Sylvania.

ROBERT F. SCHULZ was appointed manager of the division's Reconnaissance Systems Laboratory.

G. W. JONES has been appointed manager of market research at Riverside-Alloy Metal Div., H. K. Porter Co., Inc.

ROBERT W. PEARSON has been appointed director of manufacturing for American Machine & Foundry Company's Government Products Group.

ALBERT W. BUSH has been appointed sales manager, Eastern Region, for the group.

FRED W. MOORE has been appointed comptroller of Leland Electric Co. Div. and assistant secretary-treasurer of AMF.

HAROLD E. FRANCIS has been named chief project engineer of Chandler-Evans.

ERCOLE J. VITALI was named manager of the Engineering Test and Experimental Dept.

L. PAUL LEE was named to head the aluminum sales department of Joseph T. Ryerson & Sons Inc.

DR. C. BURKE MILES has been named assistant research director of the Inorganic Chemicals Research and Development Department of Food Machinery and Chemical Corp.

LARRY S. WINSTON has been named vice-president, sales, Gilmore Industries, Inc.

KARL H. EPPLE has been appointed director of engineering for the Heli-Coil Corp, a division of Topp Industries.

EDWARD W. MC LAREN has been named Director of Manufacturing.

Z. W. PIQUE has been named director of sales for the Hughes Products Group of Hughes Aircraft Co.

JAMES C. DARBY has been appointed general sales manager for the Truarc Retaining Rings Div., Waldes Kohinoor, Inc.

C. A. STILLWAGEN has been advanced to vice president, finance, and treasurer, Ryan Aeronautical Co.

H. E. RYKER has been promoted to vice president, operations.

B. K. GOODMAN was advanced to secretary.

M. K. SMITH was promoted from material manager to material director.

DUANE R. BRANAKA has been appointed sales manager of Valvair Corp.

WILLIAM JAROSCAK was promoted to assistant to the president, Midland Aircraft Corp.

R. H. OWEN was promoted to a newly-formed manufacturing engineering division at Beech Aircraft Corp.

DEREK RICHARDSON has been appointed vice president of aluminum sales, Metals Div., Olin Mathieson Chemical Corp.

WALTER KRUG has been appointed chief manufacturing engineer for Republic Aviation Corp.

WILLIAM L. VAUGHAN has been appointed manager of purchasing at the San Diego plant, Solar Aircraft Co.

KENNETH P. BOWEN has joined The Sierracin Corp., Burbank, Calif., as assistant to the general manager.

continued on next page

James C. Darby
Truarc

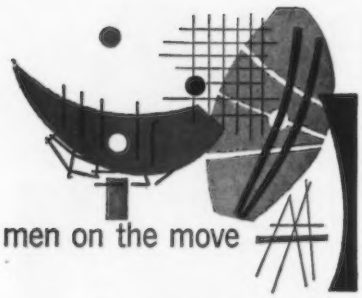
C. A. Stillwagen
Ryan Aeronautical

Duane R. Branaka
Valvair

William Jaroscak
Midland Aircraft

William L. Vaughan
Solar Aircraft

Kenneth P. Bowen
Sierracin



JACK M. PRICE was appointed assistant sales manager, Metalworking Chemicals Div., Amchem Products Inc.

FRED J. KUPEL has been appointed assistant controller of Western Design & Manufacturing Corp. and is responsible for financial operations at the Montebello, Calif., plant.

WILLIAM H. HERRMAN has been appointed to the position of director of advertising and public relations for the Hoffman Laboratories Div.

JACK C. ANDERSON was named director of military marketing.

NORBERT T. GRAINER has been appointed mid-west regional manager for General Controls Co.

ROBERT ERICKSON was named executive vice president of Beckman Instruments Inc.

D. C. DUNCAN was appointed to the new corporate position of director of contract sales.

WALTER F. DIMMICK has joined the Shockley Semi-conductor Laboratory of Beckman.

D. C. MC NEELY has been appointed acting manager for the firm's Helipot Div.

JOSEPH T. MILLER, JR., was named manager of bearing sales, Hoover Ball and Bearing Co.

ROBERT S. MILLER has been appointed president of Kavamil Co.

GERALD D. DOEDEN was appointed manager of marketing, Doeden Tool Corp.

DR. CHARLES F. ROBINSON was named chief research physicist at Consolidated Electrodynamics Corp.

DR. LELAND G. COLE was named chief research chemist.

HUBERT FRUEHAUF is manager of a new Magnesium Products Dept. at The Dow Chemical Co.

WALT SCHINDLER has been named vice president of engineering at Vard, Inc.

PHILIP LYNN is new vice president of industrial relations.

Jack M. Price
Amchem Products

Ray P. Dunn
Lindberg

Fred J. Kupel
Western Design & Mfg.

W. J. Pattison
AiResearch

Robert Erickson
Beckman Instruments

Reuel H. Smitter
Waugh Engineering

Joseph T. Miller, Jr.
Hoover Ball & Bearing

Rear Adm.
Earl E. Stone USN (ret.)
Holex

Gerald D. Doeden
Doeden Tool

John F. Murray
Borg-Warner

Hubert Fruehauf
Dow Chemical

Howard D. Weissman
DuMont

RAY P. DUNN was appointed technical director, Lindberg Melting Furnace Div., Lindberg Engineering Co.

CHESTER A. HILL has been elected vice president-assistant treasurer, Aerojet-General Corp.

DONALD J. MAC FADDEN was promoted to vice president, engineering, Koehler Aircraft Products Co.

W. G. DORAN has been named director of material for the Douglas Aircraft Co.

W. J. PATTISON becomes vice president in charge of sales for the AiResearch Manufacturing Divisions of the Garrett Corp. in Los Angeles and Phoenix.

HARRY WETZEL, manager of Garrett's AiResearch Div., Los Angeles, was elected vice president.

REUEL H. SMITTER has been appointed general sales manager, Waugh Engineering Co.

JERRY CIRAL is now manager for all Hub-Pot Inc., sales.

ROBERT F. MURRAY was appointed controller, defense products div., The Brunswick-Balke-Collender Co.

GEN. JAMES H. DOOLITTLE becomes chairman of the Board of Directors of the Space Technology Laboratories, Inc., effective January 1.

REAR ADMIRAL EARL E. STONE USN (RET.), becomes a director of Holex Inc.

ROBERT E. PINCUS has been appointed director of Mycalex Electronics Corp. and Mycalex Tube Socket Corp.

ALFRED S. BACKUS has likewise been appointed a director.

JOHN F. MURRAY was appointed chief product engineer for Pesco Products Div. and Wooster Div., Borg-Warner Corp.

DONALD R. SPATZ was appointed vice president in charge of sales for the divisions.

HOWARD D. WEISSMAN has been appointed manager of contract procedures and analysis for the military operations of Allen B. Du Mont Laboratories, Inc.

EUGENE FIORAMONTI has been appointed western regional sales manager of the Narda Ultrasonics Corp.

RAY L. REID has been appointed assistant chief engineer of Ling Electronics, Inc.

worth asking for:

technical literature listed here is available without charge from the various manufacturers

Products-services

Packet of brochures shows work of aircraft-missile designing and manufacturing firm.

Darco Industries, Inc.

Circle 208 on postcard for more data

Hexagonal Connectors

Technical bulletins on series c2 and c18 pin and socket hexagonal connectors.

DeJur-Amsco Corp.

Circle 178 on postcard for more data

Equipment Tally

Brochures available on electro-hydraulic power package, other equipment for aircraft and missiles, qualification testing methods.

Adel Precision Products

Circle 191 on postcard for more data

Plating-Testing

Electro-plating system, testing equipment described.

Nankervis Co.

Circle 189 on postcard for more data

Industrial Controls

Over 9,000 standard controls for temperature, pressure, humidity and other variables described in catalog c101-1.

Minneapolis Honeywell Regulator Co.

Circle 180 on postcard for more data

Silicone Rubber

Data sheet outlines properties of Silastic LS-53, solvent resistant silicone rubber.

Dow Corning Corp.

Circle 212 on postcard for more data

Filters

A 132-page two-color filter engineering and reference manual coverers filters for aircraft, missiles, industrial and ground support equipment.

Bendix Filter Div.
Bendix Aviation Corp.

Circle 192 on postcard for more data

Flow Elements

Pocket size booklet, "Selecting Primary Flow Elements," shows characteristics of line of nozzles, tubes.

Builders-Providence Div.
B-I-F Industries

Circle 196 on postcard for more data

Made In England

Potentiostat, electropolisher, electronic chassis assembly system, and flame chromatograph described in separate collations.

Shandon Scientific Co., Ltd.

Circle 177 on postcard for more data

Resistance Welding

New addition (vol. 5, No. 3) to "Resistance Welding At Work" series describes use with jet engine components.

Sciaky Bros., Inc.

Circle 218 on postcard for more data

Silicone Fluids

Engineering Guide to Silicone Fluids for Mechanical Applications available.

Dow Corning Corp.

Circle 198 on postcard for more data

Crucibles

16 page catalog, "Crucibles for Metal Melting," offered.

Norton Co.

Circle 182 on postcard for more data

Servo Valves

Catalog 210 on the line of low flow servo valves.

Moog Valve Co.

Circle 211 on postcard for more data

Coil Winding Machines

Latest model coil winding machines, formulas, accessories shown in new 62-page catalog 59.

Geo. Stevens Mfg. Co.

Circle 176 on postcard for more data

Connectors

Nineteen contact arrangements illustrated in bulletin on Series DTX rack and panel connectors.

H. H. Buggie, Inc.

Circle 179 on postcard for more data

Electronic Hardware

Comprehensive 75-page reference manual of standard electronic hardware.

Amatom Electronic Hardware Co.

Circle 188 on postcard for more data

Closed-Circuit TV

Bulletin GEA-6833 describes in text, tables and pictures the uses and advantages of General Electric closed-circuit television for military use. Emphasis on specialized equipment for weather briefing, night vision, slow scan, large screen projection, nucleonics or any type of hazardous operation.

General Electric Co.

Circle 217 on postcard for more data

Concrete Cutting Lance

A 4-page folder describes new powder lance capable of slicing through concrete or metal of any thickness. Accurate control of intense heat is the key to operation.

Linde Co.

Circle 183 on postcard for more data

Self-Sealing Coupling

Engineering bulletin covers new 3200 series self-sealing coupling for aircraft hydraulic systems.

Aeroquip Corp.

Circle 181 on postcard for more data

Temperature Detectors

Information about Thermohm detectors (resistance thermometers) for temperatures up to 1000°F is given in 36-page catalog EN-S4.

Leeds & Northrup Co.

Circle 187 on postcard for more data

Power Supplies

Engineering bulletin VP-858 illustrates and describes two new variable frequency power supplies.

Empire Devices Products Corp.

Circle 205 on postcard for more data

continued on next page

worth asking for:

technical literature listed here is available without charge from the various manufacturers

Regulator Repair

Illustrated Bulletin gives step-by-step instructions for installation of new seats in welding and industrial regulators in order to reduce repair charges and down-time.

Modern Engineering Co.

Circle 210 on postcard for more data

Rotary Actuators

The modulor design aircraft rotary actuator is subject of bulletin.

Airborne Accessories Corp.

Circle 174 on postcard for more data

Digital Indicating Instruments

Bulletin 1758 discusses principles and applications of servo null-balance digital indicating instruments.

Performance Measurements Co.

Circle 202 on postcard for more data

Titanium Fittings

Forged titanium fittings discussed in brochure, with types, applications, advantages, other technical data.

Harvey Aluminum

Circle 193 on postcard for more data

Tachometer Generators

A 12-page engineering report describes test procedures and test equipment used in determining stability, linearity and other characteristics of d-c tachometer generators.

Servo-Tek Products Co.

Circle 214 on postcard for more data

Gov't Specification Products

Products it supplies to meet various government specifications listed in 12-page booklet.

E. F. Houghton & Co.

Circle 207 on postcard for more data

Transistor Servo Amplifier

Brochure shows miniaturized transistor servo amplifier performance data, wiring diagrams, dimensional information.

Librascope, Inc.

Circle 175 on postcard for more data

Floor Trucks

Circular shows four-wheel floor trucks for wide variety of special and standard materials handling jobs.

Lewis-Shepard Products, Inc.

Circle 195 on postcard for more data

Radioactivity Measurement

Two-page bulletin CRM-11 describes linear count ratemeter, designed to power GM, scintillation and proportional counting detectors, and to measure radioactivity.

Nuclear Measurements Corp.

Circle 203 on postcard for more data

Data Sheet

Data sheet 104 gives comparative test data on a variety of round and rectangular tape data preservers.

Magnetic Shield Div.
Perfection Mica Co.

Circle 185 on postcard for more data

Refractory Products

Booklet, "Refractory Brick and Other Shapes for Industry" has been published to aid design engineers and operators select the proper refractory products for high temperature applications.

Norton Co.

Circle 209 on postcard for more data

Turbine Flowmeter

Turbine Flowmeter, a propeller type meter that translates liquid velocity into a millivolt signal proportional to flow rate, is described in new spec sheet 10C1505. Differential pressure transmitter shown on sheet 10B1465. Bulletin 91-120 discusses evaluation of kinematic flowmeters.

Fischer & Porter Co.

Circle 197 on postcard for more data

Impact Extrusions

Detailed engineering data book on new impact extrusion metalworking process. Technical data on alloy selection, chemical composition and mechanical properties of alloys used in the process are included.

Mueller Brass Co.

Circle 201 on postcard for more data

Small Parts

A new edition of "Small Parts for Industry" bulletin available. Covers a wide variety of zinc alloy die cast and molded thermoplastic products.

Gries Reproducer Corp.

Circle 213 on postcard for more data

Power Supply

Bulletin No. 1485 describes a 5½ oz, mil. spec. qualified power supply. Bulletin 399-100 shows flasher, with transistorized control circuit, for ground and airborne use with warning light.

Master Specialties Co.

Circle 206 on postcard for more data

Sheet Handling

Illustrated booklet describes sheet handling system.

Acme Welding

Circle 199 on postcard for more data

Hi-temp Paving

High temperature paving problems and their solutions described and illustrated in new bulletin.

Aviation Products Div.
Walter Maguire Co.

Circle 200 on postcard for more data

Data Sheet

Engineering data sheet (No. 22) describes Nicrobraz 50, new nickel-base brazing alloy for high-temperature service.

Stainless Processing Div.
Wall Colmonoy Corp.

Circle 184 on postcard for more data

Electrical Equipment

Design, testing, and manufacturing facilities for electrical equipment used by the missile industry featured in bulletin.

Crouse-Hinds Co.

Circle 190 on postcard for more data

Decade Counters

Technical product information bulletin 826 contains information on line of decade counters containing beam switching tubes and nixie indicators.

Electronic Tube Div.
Burroughs Corp.

Circle 186 on postcard for more data

Tubing Joint

Engineering details of Conoseal all-metal tubing joint given.

Marman Div. Aeroquip Corp.

Circle 216 on postcard for more data

Oscillograph

New, portable two-channel oscillograph package with built-in amplifiers is described in four-page bulletin.

Brush Instruments Div.
Clevite Corp.

Circle 204 on postcard for more data

Fix Kit

New brochure describes simplified "Fix Kit" for modification or repair of aircraft or missile structures.

Hi-Shear Rivet Tool Co.

Circle 194 on postcard for more data

Titanium Welding

"What's New in Titanium Welding" is a quick summary of the latest techniques in resistance and fusion welding of commercially pure and alloy titanium.

Titanium Metals Corp. of America

Circle 219 on postcard for more data

Components Testing

Specially designed equipment for testing missile components is treated in a new booklet.

Missile & Ordnance Systems Dept.
General Electric Co.

Circle 215 on postcard for more data

industry notes

ATLAS INERTIAL SYSTEM SMALL, LIGHT, READY

A rough rule of thumb states that every 40 or 50 pounds shaved off an ICBM's weight allows an increase in payload of about a pound.

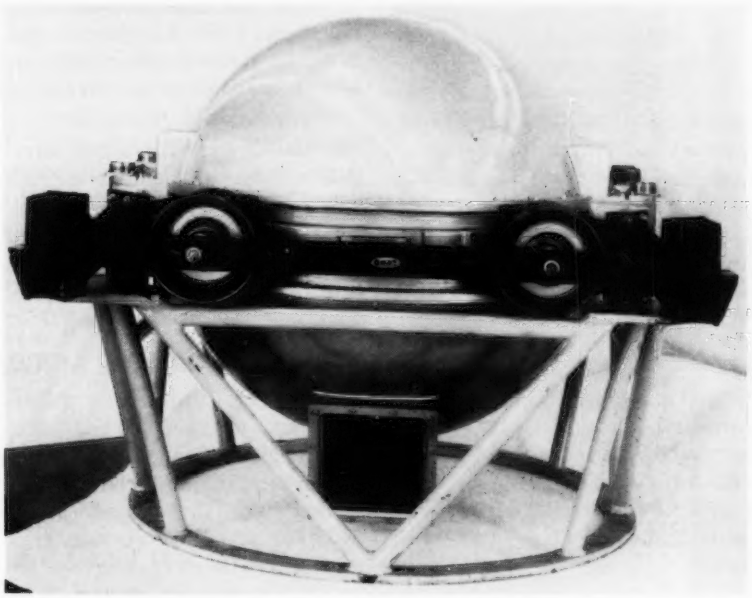
The inertial guidance system now ready for the Atlas is one of the lightest of its type using small gyros and computers and lightweight materials such as magnesium.

Future improvements should make further, substantial weight reductions. Under present planning, some essential components may be reduced as much as 90 per cent.

The system, being produced under Air Force contract by Arma Div. of American Bosch Arma Corp., Garden City, N. Y., is housed in three magnesium enclosures to eliminate dead weight and cut fuel requirements.

Two enclosures — the three-deck computer section and the control-central (power) cases—are fabricated entirely from magnesium extrusions. Two deep-drawn hemispheres in the inertial platform for the gyros, (heart of the inertial system), are of magnesium.

Most of the extrusions are AZ31B alloy but one side extrusion in the control-central case is AZ61A. Large sections of the extrusions are machined out. The hemispheres are also AZ31B alloys.

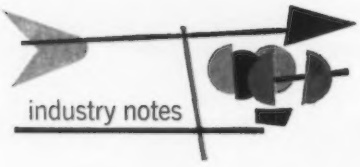


Inertial platform of system contains two deep-drawn magnesium hemispheres, has sighting window for aligning before launching.

After receiving the computer section and control-central cases, Arma installs various electronic packages in the form of cards sliding into the cases. Its system is based on the subminiature fluid-suspended gyro compass produced at Garden City. Inertial platform itself houses three accelerometers. This platform will be progressively miniaturized as research proceeds in Arma's spatial laboratories.

Flight testing of the system in Atlas is expected by late '58 or early '59. Earlier reliability tests took place on supersonic rocket sleds at the Naval Ordnance Testing Station, China Lake, Calif.

"We're ready for the Atlas now," commented an Arma



spokesman. "The only thing left is putting the complete system in the missile."

A perfect wedding of the system to the weapon takes time because of changes in the missile itself. At present, the Atlas manufactured by Convair, Div. of General Dynamics Corp., is equipped with a radio inertial system programmed for early operational capability.

Arma began work on ICBM inertial guidance systems in 1955. American Bosch Arma signed a $140,357,000 Air Force contract last March for research on guidance for the Titan ICBM. Later, when the Atlas guidance go-ahead came, work in the Titan program as prime contractor halted.

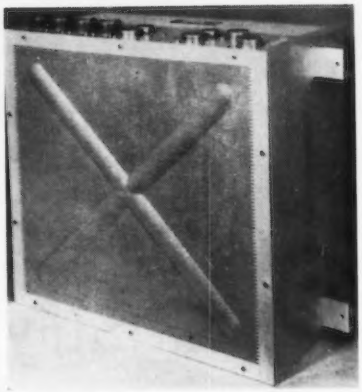
Arma plans to move back into the Titan program when production of the guidance systems has reached a high enough point. (Atlas and Titan use the same systems.)

Computer and control-central cases are supplied by the Bay City, Mich., Div. Dow Chemical Co. and by American Machine & Foundry Co., Buffalo, N. Y. Aero Trades, Mineola, N. Y., supplies the hemispheres. Mounting for the hemispheres is supplied by the Lord Manufacturing Co., Erie, Pa.

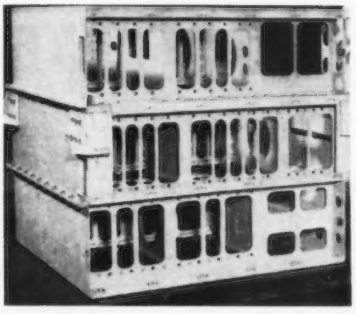
Micro - miniaturization program on the all inertial guidance system may be aided by merger of American Bosch Arma with Northrop Aircraft. This merger is expected within the next year, after stockholders' approval.

Know-how of Northrop with celestial devices for space navigation may complement Arma's inertial system.

"Applications for flight in outer space may be tremendous," said an Arma spokesman.



Control system of Atlas inertial guidance is housed in case fabricated from magnesium extrusions.



Three-deck case of Arma inertial guidance system's computer section, which calculates ICBM's velocity, uses magnesium extrusions throughout.

RADIATION EFFECTS ON NUCLEAR AIRCRAFT STUDIED

Opening this month near Dawsonville, Ga., is a large nuclear laboratory built and operated for the Air Force by the Nuclear Products branch, Georgia Div., Lockheed Aircraft Corp.

Operations building of Lockheed's Nuclear Products branch is 100 yards from reactor building. Scientists pass through 500 yard tunnel (shown in construction) and a decontamination room.

Here, bounded by mountains and charged barbed wire, an unshielded nuclear reactor will freely irradiate large component parts, systems and materials for proposed nuclear-powered aircraft.

The reactor, developed by Lockheed, the Air Force, and the General Electric Co., is submerged in a deep well when not in use. A hundred yards away, in an underground operations building reached only by a 500 yard tunnel, trained technicians will control an automatic lift hoisting the reactor to ground level for experiments.

Materials to be irradiated enter the lab on flat cars. Entire operation is automatic and watched on a closed circuit TV system. After exposure, an automatic "kicker" starts the cars downhill. A diesel engine waiting at a safe distance transports them to a cooling off area. Later, the cars will be pulled to a radiation effects lab 2½ miles away. Effects of radiation are studied by crews wielding "hot materials handling" equipment. These men from a safe vantage point can do minute instrument work with "robot hands."

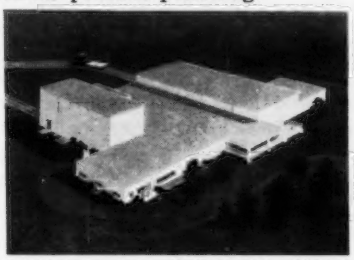
Construction on the project began in the Fall of 1956 under Air Force contract. That year Lockheed transferred work on nuclear aircraft design and production from Burbank, Calif., to its Georgia Division.

The 10,000 acre mountain site was chosen partly because the area in the North Georgia Blue Ridge mountains was sparsely settled. Mountains furnished a natural wall. A "wildlife proof" fence protects animals from radiation.

One of the first steps in construction was setting up a weather station on the site to record conditions and study past weather history for the area. Reasons: weather patterns are important in nuclear experiments, and radiation already present must be learned. A close watch will be maintained on the radiation level after the reactor "goes critical."

Entire facility cost $13.5 million. It is expected to go into full operation by February; employing 200 people, mostly scientists and technicians, in the first year. When entering or leaving the operations building, these employees will be required to pass through a decontamination room as a safety precaution.

Information obtained from the laboratory will be used in design work for future nuclear craft. Need for shielding is the reason why nuclear powered planes are heavy and slow under present planning.



Artist's drawing of Radiation Effects Laboratory, 2½ miles from reactor. Here irradiated components are studied.

Lockheed hopes to design, manufacture, install and operate various types of nuclear reactors at the new center, including some for commercial use, the Air Force permitting. The reactors might also supply heat and power to industrial plants in isolated areas.

A small zero power reactor, used to calibrate fuel elements for the large one, went critical in June.

Heart of facility reactor is installed in deep well. Later, activated, it will be submerged in water.

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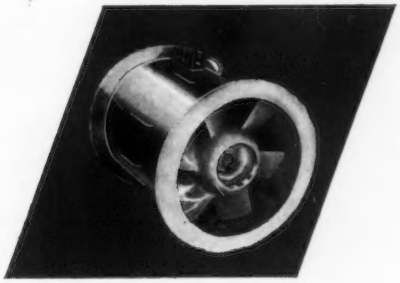

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industry notes

SOARING SALES, PROFITS RAISE AIRCRAFT EXECUTIVE SALARIES

by Douglas K. Kinsey, McKinsey & Co., Inc.

Top-management's total compensation* — including salary, bonus, and deferred compensation — in the aircraft industry is generally in line with all industry averages, a recent industrial survey has revealed.

During 1957 the survey showed also that aircraft chief executives experienced a modest 3.8 per cent average increase in total compensation, despite the general recessionary trend that prevailed in most industries where a 1 per cent average increase was noted. When this is compared with the 1956 average increase of 1.3 per cent for aircraft and 5.1 per cent for *all* industries, it is apparent that aircraft manufacturing went counter to the compensation trend for 1957.

The reason for this reversal can probably be attributed to the dramatic change in the profit picture for this group, as shown by the following net sales and profit comparisons:

Percent Increase Over Prior Year

1956	Sales	Profits
All Industries	11.0%	10.0%
Aircraft Industry	15.5	1.8
1957		
All Industries	5.3	(3.2)**
Aircraft Industry	24.3	10.7

Here the survey indicates that substantial progress was made from 1956 to 1957 in improving aircraft sales and profit margins. Consequently, the total compensation percentage increase would seem conservative in the light of past experience, but in keeping with business practice in a period of declining profits.

The Survey

Facts for this executive compensation survey were assembled by McKinsey & Company for its annual report on top-management compensation published in the *Harvard Business Review*. The survey covers 642 companies and 18 industries, and aims at measuring year-to-year change in top-management compensation as it relates to company size and industry characteristics. Company size is

*—*Separate incentive awards as such are no longer reported in the source material. It is well known, however, that a number of aircraft companies have successfully developed executive incentive plans as part of their top-management compensation program.*

**—*Decrease.*

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based on net profits, sales volume, and total assets.

Executives

Figure 1 indicates also that a typical company with net profits of $3 million in 1957 should pay its chief executive in the neighborhood of $80,000 total compensation. This compares with $74,000 total compensation based on the all-industry trend line.

Compensation paid the chief executive usually establishes the upper limit for all management compensation. As a rough guide to what is reasonable total compensation for other key top-management people, percentage comparisons for second, third, and fourth highest paid executives have been calculated.

Percentage of Chief Executive's Compensation

	All 18 Industries	Aircraft Industry
Second Highest Paid	69%	78%
Third Highest Paid	57	62
Fourth Highest Paid	52	48

It is readily seen that total compensation awarded to aircraft executives compares quite favorably with that of all industries.

Other Compensation

Industry in general continued to expand its use of special compensation plans. The aircraft companies included in the survey followed this tendency in establishing executive compensation plans in a number of special fields.

	Number of Companies	Percent of Aircraft Industry
Employee Savings Plans	None	—
Pension Plans	18	81.8
Stock Options	16	72.7
Stock Pensions	None	—
Profit Sharing Trusts	1	4.5
Consultative Contracts*	5	22.7
Deferred Contingent Compensation	None	—

*—*The consultative contract differs from deferred contingent compensation in that it is a set sum distributed over a period of years after retirement.*

FIRE-FIGHTER OF THE NEAR FUTURE

Aluminum-coated, heat-reflecting suits are entering Air Force rescue procedures.

Three piece suits, of asbestos-cotton-glass fiber material, are coated with a layer of aluminum less than six-millionths of an inch thick. Emergency crews wearing them will be able to enter hot areas without being "wet down" or covered with foam.

The Air Force has ordered 20,000 of the suits for domestic and foreign bases. Engineers at Wright-Patterson field developed specifications in a program lasting several years.

In Air Force laboratory tests, the fabric withstood 25 sec exposure to heat from a 2,550°F source.

Fitting over existing clothing, suits can be donned in 15 sec. Three pieces are: boots and pants (slipped on together); knee-length coat; hood.

Aluminum-coating process itself was developed by Minnesota Mining and Manufacturing Co. Suits are made by Flaikins Inc., New York City.

WORLD-WIDE WEATHER RECONNAISSANCE SYSTEM?

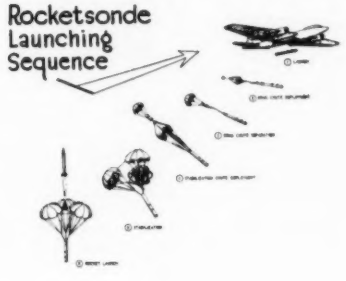
A continuous weather reconnaissance system under development will use jets, rockets, radar, and radiosondes.

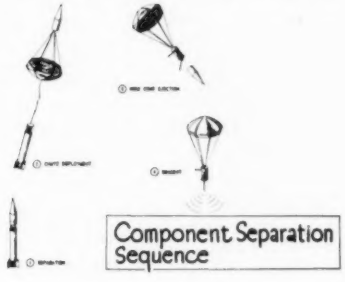
The Air Force has given initial contract for what may be a multi-million-dollar development program for weather stations to the Systems Div. of Bendix Aviation Corp.

Contract covers the first 12 months of an estimated 36-month R & D program. Boeing Airplane Co. will be chief associate of Bendix.

Stations would consist of four-engine Air Force jets flying at Mach 0.95 and 50,000 ft. Flights covering 4,500 miles would measure cloud formations and look inside storms with radar sweeps extending 150 miles. Radiosondes, instrument-equipped units, would be launched by rocket to probe the jet stream, other atmospheric phenomena as high as 150,000 ft. These units would also be dropped by parachute to "read" weather data close to the earth.

Intended primarily for the Air Force Air Weather Service, system would also be supplied to commercial air lines, the Weather Bureau and weather forecast-





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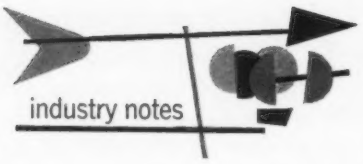


ing services. It would communicate with ground stations which then could process and relay the data over a national network.

The Bendix-Boeing engineering team, which will demonstrate system feasibility within 12 months, believes a world-wide weather prediction method could be set up.

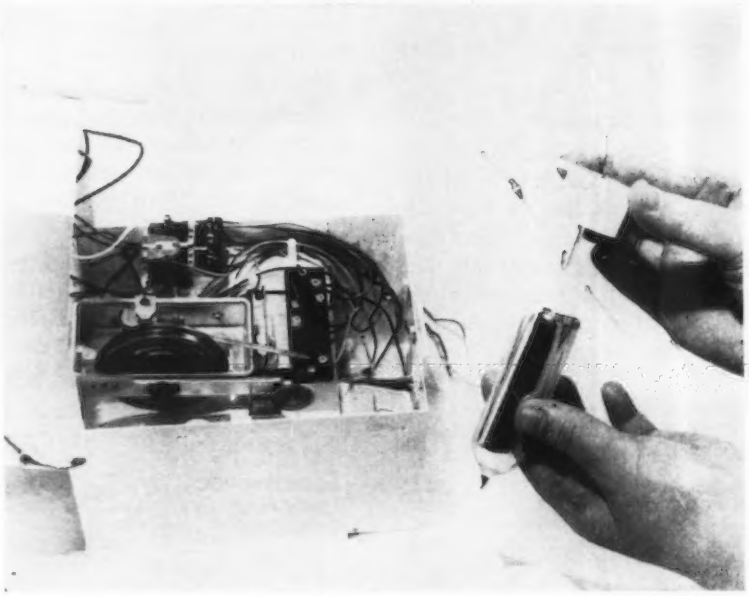
BEFORE PLATING, PEELABLE PLASTIC

A tested work horse in protective coating — butyrate peelable plastic — is reducing cost of masking metal parts, before partial plating.

Instead of lacquer-type coatings, requiring relatively long drying, the parts are dipped in molten plastic for a few moments. The plastic coating, solidifying within 60 seconds, is trimmed away from areas to be plated. After plating, remaining coating is stripped away, rinsed and returned to melting tank for reuse.

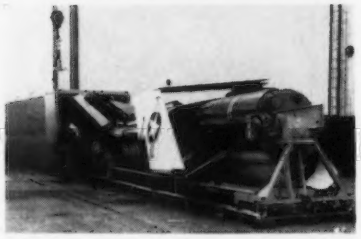
Non-exuding butyrate melt coating for plating work has been developed by Seal-Peel Inc., Royal Oak, Mich., using butyrate supplied by Eastman Chemical Products Inc., Kingsport, Tenn., subsidiary of Eastman Kodak Co.

HYPSOMETER RADIOSONDE

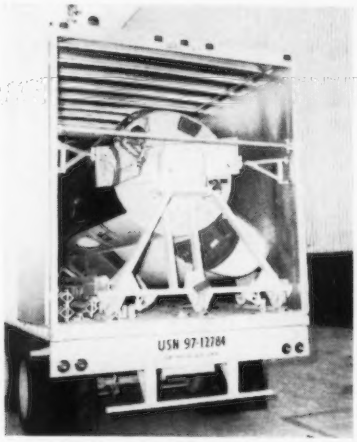


New weather detector is being produced for missile program weather research by General Instrument Corp. Two inch vacuum flask, "hypsometer," is filled with 5 cc. of carbon disulphide which boils at low pressures and temperature. Fishhook-like "thermistor" inserted in neck, reads temperatures of boiling liquid. Electronic circuitry in eight inch "radiosonde" (left), which contains hypsometer, beams information to ground. Quick computation of atmospheric pressure and altitude follows.

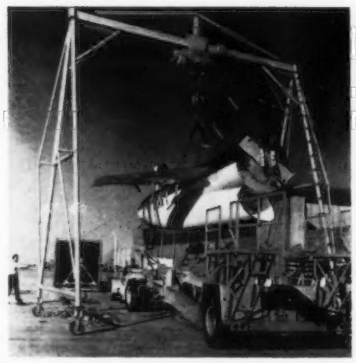
MISSILE MOBILITY



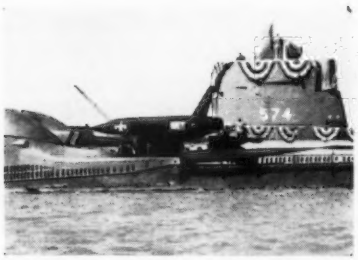
Wings folded, aft section of Regulus II guided missile is loaded on dolly before being pushed into special transport van at Chance Vought's Dallas, Tex., plant.



In van, rear section of Regulus is held in position by braces.

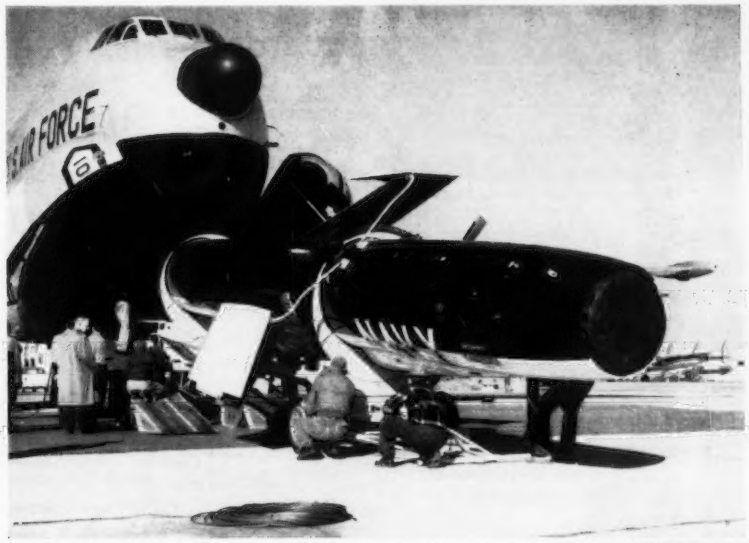


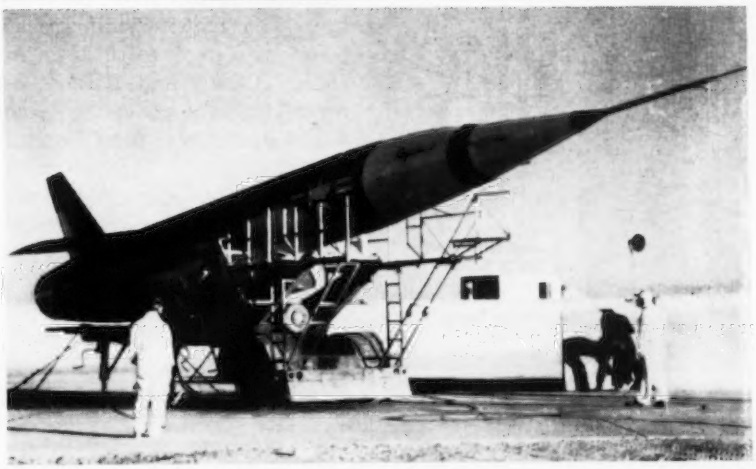
Truncated aft body is lowered into hangar trailer, where it will be joined to the forward section.



Regulus on launcher of U.S.S. Grayback. It is housed in hangars at left.

Nose section of Regulus II is perched in dolly after being unloaded from van. Below, missile goes into C-124 Globemaster.





Missile, designed for submarines, can also be fired from a four-wheeled mobile launcher with jet assist. Here, fully assembled, it is poised at Edwards Air Force Calif. Base. Tractor can pull 1,000-mile-range missile on its mobile base.

"TORQUE WRENCH" MANUAL

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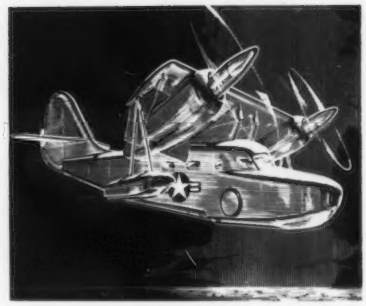
industry notes

VTOL-STOL AIRCRAFT

Kaman K-16B, research aircraft proposed for both short and vertical takeoffs, would use "propeller-rotor" concept developed by Kaman for the Navy.

Rotors tilt upwards for takeoff. Controllable servo flaps on the blades give positive control. Large extensible flaps on wing provide additional lift. Takeoff is on deflected slipstream principle.



Conventional controls (rudders, elevator, and ailerons) are not effective at slow takeoff speed. Above 50 mph, flap control system automatically phases out, regular controls take over, wing is changed to horizontal.

LIQUID FLUORINE HARNESSED FOR ROCKETS

Use of liquid fluorine in rocket propulsion is regarded as one of the most significant breakthroughs in U. S. chemical rocket know-how.

The powerful oxidizer is being used in successful rocket thrust chamber firings at Bell Aircraft Corp's Rockets Div.

Breakthrough led to predictions that payload increases as high as 70 per cent can be achieved with existing ballistic missiles.

Combined with existing fuels, fluorine increases power output from 22 to 40 per cent. Bell spokesmen said rocket boosters similar to those in existing ICBM's and IRBM's become powerful enough to place vehicles "larger than Sputnik III" in orbit.

Present propellant combinations, such as liquid oxygen and kerosene, yield sea level specific impulse of about 245 lb of thrust per second per lb of propellant consumed. With liquid fluorine as oxidizer thrust could be increased from 300 to 345 lb, depending upon fuel.

The fluorine research took place in Bell's Niagara Frontier Div., coordinated with the Power Plant Lab of the Air Force's Wright Air Development Center, sponsor of the R & D work.

Because of its high power —it even combines with water to produce a combustion temperature of 5,000°F—the oxidizer has caused speculation that it will replace liquid oxygen.

Besides developing the liquid fluorine, Bell developed the engine for the firings. Its material has not been revealed but is able to withstand "tremendous heat," according to Bell.

Because liquid fluorine packs much more thrust and heat than conventional oxidizers, its use in Atlas ICBM would call for changes to strengthen the missile's walls. It might also mean different metals for the missile structure. Bell Aircraft, which developed the oxidizer and built an engine for it, may be using hydrogen or lithium as the fuel. These have high specific impulses.

Before liquid fluorine could be used, special handling procedures would have to be set up. It must be kept at minus 306°F.

NEW GYRO ASSEMBLY INSTALLATION

Kearfott Co., Inc., recently completed a new "plant within a plant" designed and constructed expressly to house precision production facilities for floated rate integrating gyros.

Occupying 4000 square feet of floor space, and completely self-contained, this dust-free, surgically clean glassed enclosure is also fully integrated for maximum efficiency of parts handling. Air filtration system eliminates 99.95% of all airborne contaminants measuring 0.3 microns (.00001 in.) or more in diameter.

Each room has controls which assure a constant temperature of 75°F and a relative humidity of 40%. In the ultrasonic cleaning room, where maximum atmospheric depuration is a critical function, the air is completely replaced every 18 seconds. In the final assembly area a complete air change is accomplished every 48 seconds. Remaining sections have an average complete air change every 75 seconds.

In the final assembly section, air pressure is maintained at three pounds per square foot above normal atmospheric pressure, and decreases linearly from one compartment to the next. Same scrupulosity holds true in preassembly section (illustration).

Walls and ceiling are covered with smooth vinyl plastic. Floors are covered with continuous strips of black vinyl sheeting to easily detect any dust.

After entering the initial decontamination anteroom, employees first clean their shoes by means of a vacuum brush, walk on a tacky gelatin mat removing dirt from shoe soles, then step on an electric floor treadle mat actuating an overhead multi-directional high velocity air shower for 15 seconds.

In the locker room they don white nylon caps, white nylon boots, and tan Orlan coveralls.

Assembly area has a higher standard of cleanliness than an operating room.

NEW GIANT
narda
SONBLASTER

Generator G-5001
500 watts output

Transducerized Tank NT-5001
Capacity: 10 gallons
Dimensions: 20" L x 11½" W x 10" D

Generator features tank selector and load selector switches on front panel to operate one or two NT-5001 tanks alternately. Other combinations of tanks and submersible transducers available from stock; larger tanks available on special order.

$1325

For mass-production cleaning and high capacity chemical processing!

Here's a new Narda SonBlaster ultrasonic cleaner with tremendous cavitation activity and generating capacity! Featuring full 500 watts output, this SonBlaster is available with a fully transducerized giant 10-gallon capacity tank. In addition, it will operate from six to 10 Model NT-605 high energy submersible transducers, at any one time, in any arrangement in any shape tank you need up to 70-gallon volume.

Install this new Narda SonBlaster, and immediately you'll start chalking up savings over costly solvent, vapor or alkaline degreasing methods! You'll save on chemicals and solvents, cut maintenance and downtime, eliminate expensive installations, save on floor space, and release labor for other work. But perhaps most important, you'll clean faster, cut rejects, and eliminate bottlenecks.

Whether you're interested in mass-production cleaning or degreasing of mechanical, electronic, optical, or horological parts or assemblies ... rapid, quantity cleaning of "hot-lab" apparatus, medical instruments, ceramic materials, electrical components or optical and technical glassware ... or in speeding up metal finishing and chemical processing of all types — you'll find this new SonBlaster will do your work faster, better and cheaper. Write for more details now, and we'll include a free questionnaire to help determine the precise model you need. Address: Dept. AMM-20.

Consult with Narda for all your ultrasonic requirements. The SonBlaster catalog line of ultrasonic cleaning equipment ranges from 35 watts to 2.5 KW, and includes transducerized tanks as well as immersible transducers which can be adapted to any size or shape tank you may now be using. If ultrasonics can be applied to help improve your process, Narda will recommend the finest, most dependable equipment available for immediate delivery from stock—and at the lowest price in the industry ($175 up)!

For custom-designed installation and unique electro-acoustic applications, including cleaning, soldering, welding, drilling and non-destructive testing, consult our subsidiary, Alcar Instruments, Inc., at the address below.

the narda ultrasonics corporation
625 MAIN STREET, WESTBURY, L. I., N. Y.
Subsidiary of The Narda Microwave Corporation

Circle 127 on Inquiry Card, page 81

industry notes

BILLIONS APPROPRIATED FOR AIR FORCE DEFENSE

Air Force slice of the Fiscal Year 1959 $39.6 billion military defense budget amounts to $17.9 billion.

The 85th Congress provided about $6.6 billion for USAF aircraft and related procurement and $743 million for research and development. Operation and maintenance of Air Force equipment is budgeted at about $4 billion.

The Navy received over $2 billion for aircraft and related procurement, $821 million for research and development.

The Army got about $1.7 billion for procuring equipment and missiles.

ARPA (Advanced Research Projects Agency) obtained $520 million, the bulk going for space flight projects.

SPACE APPLICATIONS FOR AIRSTEEL X-200

X-200 is ready for high-stress flights.

Product of over two years' research, it can stand 280,000 lb per square inch.

Producer: U. S. Steel Corp., which has designated it in its lab tests as Airsteel X-200, a new high strength alloy sheet steel for missiles and rockets.

Airsteel X-200 is made of alloying elements which harden through air-cooling into an exceptionally strong steel. The alloy is first produced at the mills in annealed "soft" condition, then heated, then cooled and tempered for high tensile strength.

Most other alloy steels need elaborate oil or salt quenching to develop equivalent properties.

The new steel gives great strength to welded joints, according to weldability studies. It is believed highly suitable for missile applications including large thin-wall motor cases.

Plastic adhesive used in bonding metal to metal in Lockheed Electra is "Plastilock 638" developed by B. F. Goodrich Industrial Products Co. Shown being applied to an interior panel, it creates a semi-elastic bond with strength greater than 4,000 lb per square inch. It is supplied in the form of tape.

BOEING TEAM RECEIVES DYNA-SOAR ASSIGNMENTS

Following basic responsibilities have been announced for members of Boeing Aircraft Company's team in the Dyna-Soar boost-glide aircraft competition.

Launching base design—Architectural and Engineering Div., Aerojet General Corp.

Pilot capsule and escape mechanisms — Chance Vought Aircraft Inc. Boost rocket systems—Boost Rocket Div., Aerojet-General Corp.

Tracking and telemetering system — General Electric Co.

Reconnaissance system—Ramo-Wooldridge Corp.

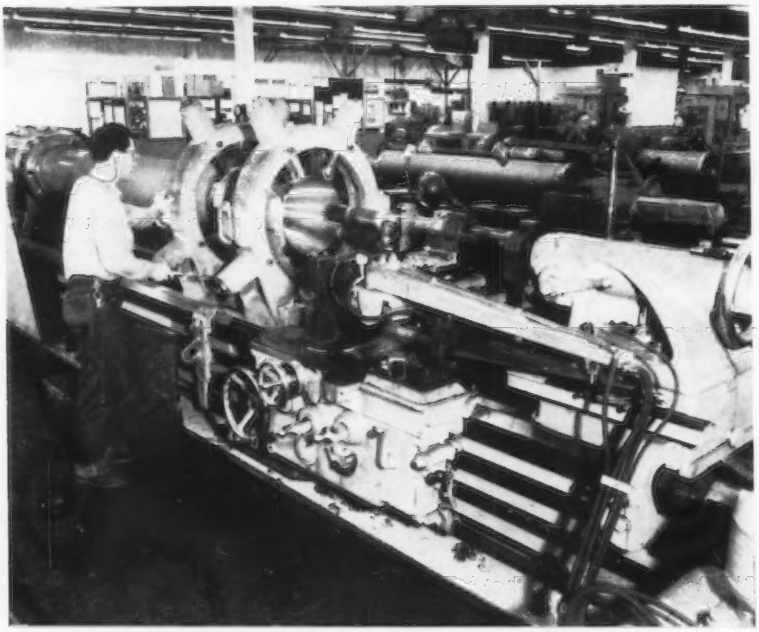
Automatic flight and landing system — Autonetics Div., North American Aviation, Inc.

First stage booster—Missile Development Div., North American Aviation.

Radio guidance system—Avionics and Electronics Div., Goodyear Aircraft Corp.

High resolution radar—Radio Corp. of America.

Boeing's Seattle Div. will be responsible for assembly. Its Pilotless Aircraft Div. has charge of system demonstration and test.



MISSILE HARDWARE MACHINED

Heavy duty lathe with swiveling air-gage tracer corrects slightest bore distortion in welding or heat-treating of rocket engine case assembly for NIKE anti-aircraft missile. Weldment, a 4130 steel nozzle, tube and forward ring, also gets final thrust alignment for fin attachment rings. Tracer and 44-in-swing Monarch heavy-duty lathe are at the Goodyear Aircraft plant, Akron, O.

TARGET . . . MOON

First Air Force IGY lunar probe attempt on August 17, lasting only 77 sec, tainted solid technical accomplishments with frustration.

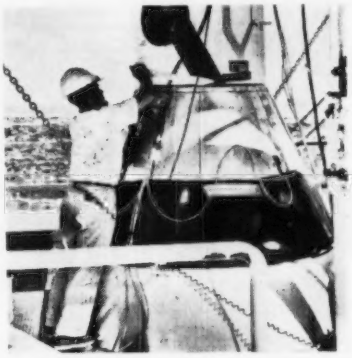
Interviews with technical people by AMM's representative revealed that engineers met crash schedule deadlines despite having some of the electronic equipment for the payload capsule still in the "breadboard" (preliminary) stage a week before firing.

A packaging miracle took place for some of the equipment. Transistorization of the Doppler receiver in the payload, for example, reduced equipment, previously as big as a trailer truck, to size of a shoe box.

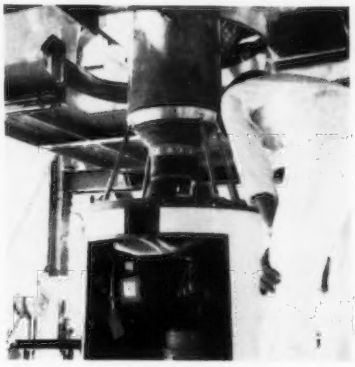
Among the other feats: modification of the Naval Ordnance Test Station TV camera and transmitter to requirements of the payload capsule; development of special coatings to dissipate heat from capsule surface; new, extensive aerodynamic calculations.

Prime contractor was Space Technology Laboratories of Ramo-Wooldridge Corp.

First stage moonprobe vehicle, Air Force Thor IRBM, is hoisted into vertical position within gantry.

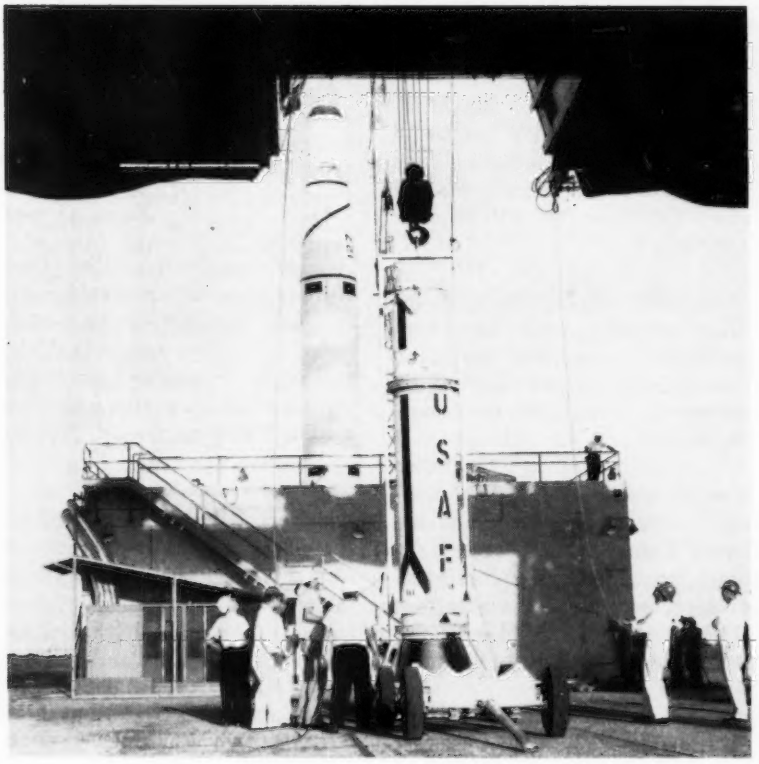


Mated first and second stages receive final adjustments.

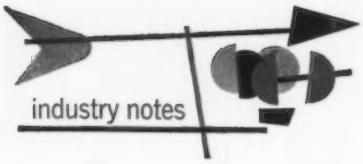


Third stage, a solid propellant rocket manufactured by the Alleghany Ballistic Laboratory is joined to second stage.

Second stage, modified Vanguard with Aerojet-General 1040 liquid propellant engine, about to be raised.



Complete vehicle stands ready. Single upper housing covers final solid propellant rocket stages and payload instrument package.



Commercial production of hot rolled copper strip from metal powder is now possible at savings up to 80 per cent. Process developed by E. W. Bliss Co. and Chemetals Corp. gives strip of high mechanical properties, low oxygen content. System may be applied to nickel and other metals.

•

Satellite information center at New Downey, Calif. Aero-Space Laboratories of North American Aviation's Missile Div., will publish significant research discoveries. Laboratories will also study space dynamics, nuclear propulsion, re-entry problems, survival in space.

•

Government procurement of a host of commodities up to $2500 is slated to go through small firms. Measure passed this year pushed range up from old limit of $500.

•

New government-operated "Defense Metals Information Center" is disseminating data on titanium, beryllium, high strength alloys, other metals. It includes consulting service and research. Location: Battelle Memorial Institute, 505 King Ave., Columbus 1, O.

•

North American A3J Vigilante newest Navy attack weapon system, has successfully passed its first functional check flight.

•

Stainless steel heat exchangers and accessory equipment for Atlas, Thor and Jupiter will be manufactured by Technical Products Div., Waste King Corp. under a $300,000 contract from Rocketdyne Div. of North American Aviation.

TERRA-SCOPE

Research laboratories of Armco Steel Corp. has developed a method to detect zinc on surface of stainless steel sheets by testing with filter paper dipped in dithizone.

•

New rocket motor developed and built by S.E.P.R. is powder driven, produces 105 tons per sec of impulsion.

•

Information disclosed by Explorer 4 satellite indicates intense cosmic ray intensities pose a problem for manned satellites "significantly higher than the ionosphere." Air Force says "an adequately large region" still remains between ionosphere and the belt for low-flying manned satellites.

•

Precision Lapping Co., Valley Stream, N. Y., says an exclusive new process makes possible bonded irdomes "of unlimited size," with shapes ranging from spherical sections, aspherics, flats, polyhedrons of bonded flat plates, or combinations of the above.

•

Crusader II (F8U-2) has made its first flights and is set to be Navy's top fighter after delivery early next year. Next step after this: Crusader III F8U-2 flies near Mach 2.

•

Marquardt Aircraft Co. and Applied Radiation Corp. have formalized an agreement for joint development in ion and other electrical propulsion for space flight.

•

Fastest mechanical "light chopper," developed by Westinghouse Research Lab, cuts light beam into pulses a few billionths of a second long. Used to test electronic devices, pulses come from a beam reflected from a six-sided rotating mirror, surrounded by five stationary mirrors, inside a cylinder.

New MIG (miniature integrating gyro) gets first use in Army's solid-propellant Sergeant missile. Inertial gyro, only 2½ inches long, manufactured by Aeronautical Div., Minneapolis - Honeywell, has sensing capabilities of larger "floated" gyros. Manufacturer: Aeronautical Div., Minneapolis-Honeywell Regulator Co.

•

Liquid-energy fuel plant, covering 300 acres, is near completion at Muskogee, Okla. Costing $38-million, it will be operated by Callery Chemical Co., for the Navy.

•

Missile ships of the future are expected to travel much faster because of "super - cavitating" ship propellers breaking down the vapor pocket hindrance existing behind ordinary propellers.

•

Two Alouette II jet-powered helicopters were delivered to commercial operators in the U. S. and Canada. Purchasers: Autair Helicopter Service Ltd., Montreal.

•

Cessna 210, available late next year, is supposed to include advanced design features never tried before on a commercial single-engine plane.

•

Air Defense Command and Civil Aeronautics Administration are expected to begin joint use of 31 new long-range radar facilities this Fall. Extensive reprogramming guided by permanent Joint Radar Planning Group, has led to linkup.

•

Air Force says infrared and ultraviolet rays may prove valuable in tracking high altitude targets. Rays have been measured in 16 mile high balloon flights from Holloman Air Force Base, N. M., they have certain advantages over radar, at high altitudes, Air Force says.

Kaman Aircraft and Fairey Aviation Co. Ltd., have concluded an agreement licensing Russia will put up a manned reconnaissance satellite before us. Arrangement would include both military and commercial rights for the U. S. and territories.

•

Pioneer aerodynamicist Dr. Theodore Von Karman implied Russia will put up a manned reconnaissance satellite before us. Russia probably has more reason to do so than we, he said, because our radar and other equipment can get much of the same information without a man. We could do the trick in two years if a full program were begun now, he added. Stating privately that the Russian satellite would probably be a true reconnaissance vehicle, he called Russian advances in exact quality control "a very sad thing." More U. S. quality control is imperative, in his opinion. He recalled a case where a labor organization handicapped "any real control of development." Von Karman then suggested the U. S. is "working to get too much performance out of solid propellents . . . maybe it's better to get less power but greater accuracy." Closing, he called for more long-run attention to nuclear rockets.

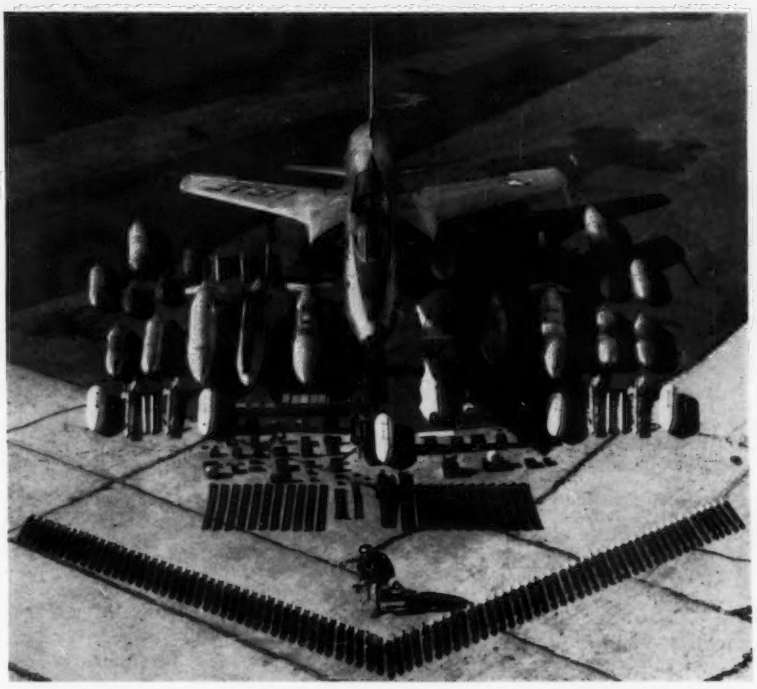
•

The Reynolds Metals Co. claims the largest heat-treated aluminum plate ever rolled, weighing nearly six tons. Plate, produced by casting an ingot of almost 12 tons, measured 55 ft long, seven ft wide and 2½ in. thick before trimming. It was made by Reynolds' McCook, Ill., plant and will be a vacuum chuck in Lockheed's aircraft skin mill, Burbank, Calif.

•

The Navy gets first eight of 132 portable Jet-noise sound supressors this month. Reduction in sound level is about 12 per cent. More advanced units under development may reduce sound as much as 90 per cent.

ARMAMENT I.Q. TEST



Included in this array of armament for the Republic F-105 fighter bomber are rockets, Gatling-type Vulcan machine gun with ammo, radar gear, liquid oxygen container, electronic sensing devices, Sidewinder missiles, high explosive bombs, fire bombs, extra fuel tanks. One man bomber, set for Tactical Air Command next year, carries 13,000 lb, can deliver an atomic bomb. Can you identify?

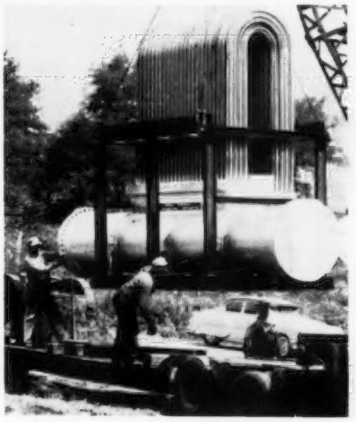
SIX MILES OF TUBING IN HEAT EXCHANGER

Six miles of stainless steel tubing are contained in a large four-stage heat exchanger recently delivered to Allison Div., General Motors Corp.

The exchanger, one of the largest of this design ever built, raises the temperature of 560 lb of air per sec from 350° to 700°F. It is used in a gas-turbine aircraft engine test program.

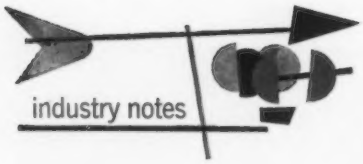
Designed and manufactured by Thermal Research and Engineering Corp., Conshohocken, Pa., the equipment heats air in more than 400 U-shaped lengths of type 321 welded stainless steel tubing stabilized with titanium. Operating temperature is such that carbide precipitation and loss of corrosion resistance would occur with conventional stainless steel.

The 1½ O.D. x 16 tubing was manufactured by the Alloy



Tube Div., Carpenter Steel Co., Union, N. J. Air enters inlet header of each stage, picks up heat in the tubing and flows out through a discharge header. Each stage is fired by six high velocity oil burners.

Initially, products of combustion have velocity of 300 to 500 ft per sec due to high rate of heat release in a small space.



INDUSTRY STATISTICS

Source: Bureau of the Census and Civil Aeronautics Administration.

VALUE OF NET SALES AND BACKLOG OF COMPLETE AIRCRAFT, AIRCRAFT ENGINES, AND PROPELLERS

All data are in Thousands of Dollars

NET SALES

Product and Type of Customer	Six Months 1958	Six Months 1957
Complete Aircraft and Parts		
For U. S. Military Customers	$2,752,000	$2,667,000
For Other Customers	553,000	587,000
Total—Aircraft and Parts	$3,305,000	$3,254,000
Aircraft Engines and Parts		
For U. S. Military Customers	$ 945,000	$1,028,000
For Other Customers	160,000	203,000
Total—Engines and Parts	$1,105,000	$1,231,000
Aircraft Propellers and Parts		
For U. S. Military Customers	$ 78,000	$ 52,000
For Other Customers	20,000	24,000
Total—Propellers and Parts	$ 98,000	$ 76,000
Total—U. S. Military Customers	$3,775,000	$3,747,000
Total—Other Customers	$ 733,000	$ 814,000
Other Products and Services	$1,216,000	$1,124,000
Total—All Products	$5,724,000	$5,685,000

BACKLOG

Product and Type of Customer	June 30 1958	June 30 1957
Complete Aircraft and Parts		
For U. S. Military Customers	$ 5,951,000	$ 7,600,000
For Other Customers	2,697,000	2,893,000
Total—Aircraft and Parts	$ 8,648,000	$10,493,000
Aircraft Engines and Parts		
For U. S. Military Customers	$ 1,991,000	$ 2,809,000
For Other Customers	565,000	706,000
Total—Engines and Parts	$ 2,556,000	$ 3,515,000
Aircraft Propellers and Parts		
For U. S. Military Customers	$ 69,000	$ 149,000
For Other Customers	25,000	39,000
Total—Propellers and Parts	$ 94,000	$ 188,000
Total—U. S. Military Customers	$ 8,011,000	$10,558,000
Total—Other Customers	$ 3,287,000	$ 3,638,000
Other Products and Services	$ 2,424,000	$ 2,108,000
Total—All Products	$13,722,000	$16,304,000

NUMBER AND VALUE OF CIVIL AIRCRAFT SHIPMENTS

Month	Units 1958	Units 1957	Value in Thousands 1958	Value in Thousands 1957
January	579	584	$ 62,311	$ 48,431
February	510	523	65,046	49,278
March	697	675	35,133	46,636
April	704	657	47,496	57,980
May	622	672	35,113	84,136
June	589	590	25,455	69,497
July	501	525	41,037	70,649
August		519		62,990
September		466		54,911
October		474		45,687
November		516		47,213
December		544		44,856
Total—Year		6,745		$682,264
Total—7 Mos.	4,202	4,226	$311,591	$426,607

AIRFRAME WEIGHTS OF CIVIL AIRCRAFT SHIPMENTS

Month	Thousands of lbs. 1958	Thousands of lbs. 1957	Avg./Aircraft 1958	Avg./Aircraft 1957
January	1,909.9	1,574.9	3,299	2,697
February	1,891.4	1,554.0	3,709	2,971
March	1,313.2	1,625.6	1,884	2,408
April	1,606.4	1,886.6	2,282	2,871
May	1,293.4	2,558.0	2,079	3,806
June	1,068.1	2,114.0	1,813	3,583
July	1,404.1	2,096.0	2,803	3,992
August		1,950.6		3,758
September		1,641.1		3,522
October		1,456.5		3,073
November		1,480.8		2,870
December		1,430.8		2,630
Total—Year		21,368.9		3,168
Total—7 Mos.	10,486.5	13,409.1	2,496	3,173

SHIPMENTS OF PISTON ENGINES FOR CIVILIAN AIRCRAFT

Month	Units 1958	Units 1957	Value 1958	Value 1957
January	1,033	920	$ 8,883,000	$ 12,445,000
February	1,139	902	9,696,000	13,596,000
March	994	1,010	8,174,000	13,975,000
April	881	950	8,174,000	14,388,000
May	828	1,020	6,176,000	15,160,000
June	783	933	5,994,000	15,636,000
July	730	801	4,898,000	12,748,000
August		776		8,603,000
September		728		10,150,000
October		921		13,638,000
November		878		9,880,000
December		1,020		12,237,000
Total—Year		10,859		$152,456,000
Total—7 Mos.	6,388	6,536	$ 51,995,000	$ 97,948,000

TOTAL HP. OF AIRCRAFT PISTON ENGINE SHIPMENTS FOR CIVILIAN USE

Month	Total Hp. (in Thousands) 1958	Total Hp. (in Thousands) 1957	Avg. Hp. per Engine 1958	Avg. Hp. per Engine 1957
January	459.9	604.4	445	657
February	518.2	647.0	455	717
March	440.7	679.2	443	672
April	428.0	668.2	486	703
May	338.3	715.8	409	702
June	328.7	730.4	420	783
July	282.1	590.4	386	737
August		425.6		548
September		482.8		663
October		628.3		661
November		473.0		539
December		586.2		575
Total—Year		7,231.3		666
Total—7 Mos.	2,795.9	4,635.4	438	709

readers' orbit

No Duplications

. . . like AMM very much because the articles are not "duplications" found in other magazines . . . you are filling a gap rather than duplicating as others do. Also, your subjects are interesting and useful . . . would like to see more on rotary wing aircraft.

E. K. Liberatore
research consultant
Rotary Wing

Error—Men on Move

. . . Thank you for your note congratulating me on my recent appointment. . . .Your announcement, however, was incorrect in that it read "president-manufacturing." . . . This is quite possibly a typographical error. . . . I call it to your attention so that your records and mailing list can be changed to read "vice president-manufacturing."

George A. Lagassa
vice president-
manufacturing
Titeflex, Inc.

Automated Machine Tools

. . . the article covering our automated line was indeed very interesting (AMM, June, 1958) . . . many thanks for a fine article.

Douglas M. Considine
director marketing
Hughes Products

Hard Anodizing Magnesium

. . . We certainly appreciate the treatment given to our technical article in the June issue of AMM. . . . We are doing considerable research on new precesses . . . these, if successful, will be completely unique, and to the best of our knowledge have not been successfully accomplished to date . . . we will give your magazine first opportunity to review and publish these processes.

Roy E. Klotz
vice president
Anadite, Inc.

Take Off The Blinders

. . . Congratulations on your intelligent approach to a serious problem (Design Visibility Into Airline Cockpits, August, editorial orbit) . . . it is time our truly technical publications started pointing out this serious deficiency in some of the most advanced machines yet contrived for public transport . . . as you point out, visibility is not the whole answer but . . . it certainly won't hurt to take off the blinders until adequate and reliable radars or anti-collision devices are developed.

Pete Matej
design specialist
Aircraft Structures

Missile Bugaboo

. . . have just finished reading the very fine article "Missile Bugaboo-Attaining Reliability" in the August issue of AMM . . . wish to congratulate your staff and the writers on the excellent presentation of the plan. . . . I plan circulating the article to the various missile design engineering sections of our company (at Cooke AFB) . . . and would appreciate reprints.

E. P. Sullivan
reliability engineer
in charge
Douglas Aircraft Co., Inc.

. . . we believe this (25 reprints of Missile Bugaboo) will be most helpful in our operations in the production planning department at McDonnell Aircraft Corp.

H. W. Stelzleni
asst. project planner
McDonnell Aircraft Corp.

. . . am favorably impressed by the development and presentation of the article "Missile Bugaboo . . ." in August AMM.

Norman A. Levin
staff quality control
engineer
electronics division
Stromberg-Carlson Co.

. . . we have recently inaugurated a Reliability Program at Sundstrand and are interested in obtaining information on the subject . . . it is requested that you send us . . . "Missile Bugaboo. . . ."

W. S. Howell
section manager
Sundstrand Aviation

Eds. and authors were pleased with overwhelming reception of this article. Engineers from 32 separate companies completely depleted reprint stock. More on reliability coming.

Who Supplies Aluminum

. . . I will not kid you about why I am writing this letter even though I find your magazine very interesting and useful in my work . . . in June "Vanguard Details Revealed" you inferred that alloy 6061-T6 was either developed by Reynolds or is supplied primarily by Reynolds for use in Vanguard. . . . I do not know the source of Mr. J. P. Kushnerick's information, but would like to advise that this alloy was developed by Alcoa . . . and Alcoa is also a major supplier for this (Vanguard) scientific vehicle. . . .

E. H. Spuhler
manager, aircraft section
sales development div.
Aluminum Co. of America

Inferences of alloy development were of reader Spuhler's own making. Source of information was naturally Reynolds, and approved by Martin. Apologies. There is actually little way of knowing who is the major supplier of aluminum on Vanguard or other projects at Martin. Metal is held in stock from several sources and is used by alloy designation or specification only, without regard to name of supplier. Hence, Alcoa, Kaiser, and Reynolds sheet stock may be used side by side on same vehicle. The same practice is applicable to steel sheet stock.

◆

september 29-october 3
semi-annual meeting and western tool show
american society of tool engineers
los angeles, calif.

◆

september 29-october 4
national aeronautic meeting
society of automotive engineers
los angeles, calif.

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october 6-7
symposium on extended range and space transmission
institute of radio engineers,
george washington university
washington, d.c.

october 8-10
aviation spark plug and ignition conference
champion spark plug co.
toledo, o.

◆

october 13-15
asme-asle lubrication conference
los angeles, calif.

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october 13-15
national electronics conference
chicago, ill.

◆

october 16-17
conference on industrial hydraulics
armour research foundation
chicago, ill.

october 22-24
national vacuum symposium
san francisco, calif.

◆

october 23-25
simulation conference
institute of radio engineers
dallas, tex.

◆

october 26-28
midyear meeting
laboratory apparatus and optical sections
scientific apparatus makers asso.
rye, n. y.

◆

october 27-28
conference on aeronautical and navigational electronics
institute of radio engineers
baltimore, md.

◆

october 30-31
electron devices meeting
institute of radio engineers
washington, d.c.

◆

october 24-november 2
international aircraft and small car exhibition
international sports car and light plane exhibitions inc.
chicago, ill.

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The TITAN "Target" Hex Collet Stud Driver drives the stud by pitch diameter pressure instead of pressure on the top of the stud. This method completely eliminates mutilation and stretching of stud threads, and distortion of cotter key holes.

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	Page
Dean & Benson Research, Inc.	67
Electric Steel Foundry Co.	1
Formica Corp.	9
Gear Grinding Machine Co.	15
Hamilton Tool Co.	68
Kaman Aircraft Corp.	70
Marotta Valve Corp.	3
Narda Ultrasonics Corp.	73
Randall Engineering Corp.	Back Cover
Rolle Mfg. Co.	Inside Front Cover
Sturtevant Co., P. A.	72
Temco Aircraft Corp.	4
Titan Tool Co.	80
U. S. Army Corps of Engineers	25
U. S. Flexible Tubing Co.	72
Vinson Mfg. Co.	Inside Back Cover

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21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300

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41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300

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21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300

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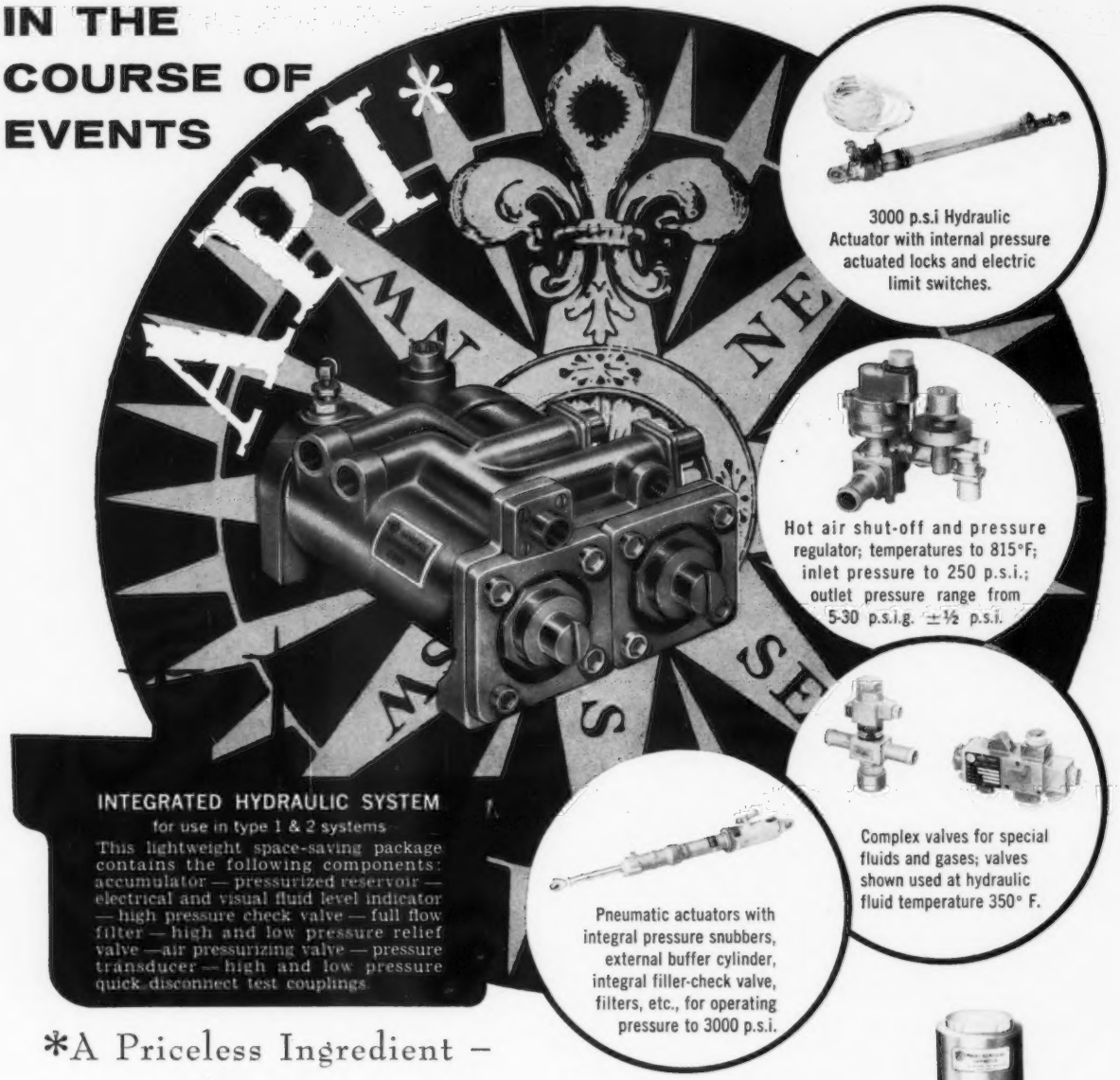

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